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DIRTY BOMBS AND BASEMENT NUKES: THE TERRORIST NUCLEAR THREAT

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BEFORE THE

COMMITTEE ON FOREIGN RELATIONS
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DIRTY BOMBS AND BASEMENT NUKES: THE TERRORIST NUCLEAR THREAT

WEDNESDAY, MARCH 6, 2002

U.S. SENATE,
COMMITTEE ON FOREIGN RELATIONS,
Washington, DC.

The committee met, pursuant to notice, at 9:30 a.m. in room SD–419, Dirksen Senate Office Building, Hon. Joseph R. Biden, Jr. (chairman of the committee), presiding.

Present: Senators Biden and Nelson.

The CHAIRMAN. The hearing will please come to order. Good morning, gentlemen. Thank you so much for being here. Let me explain, I have already explained to three of our five witnesses today the scheduling dilemma, and I want to explain to the public and the press that is here our circumstances. We have a number of things going on today, not the least of which is, Senator Helms and I, along with our counterparts in the House, have been asked to meet with the President at 10:30, and the President is fulfilling his commitment of briefing us on some detail on foreign policy matters.

As you know, there is a little bit of, as they say, a dust-up in the press as to whether we are being informed. We are being informed, and part of that is meeting with the President today, but as we all know, President's schedules are busier than Senators' schedules, which is fully understandable, and we were unaware of this meeting until yesterday.

In addition to that, Senator Lugar and Senator Hagel, both are keenly interested in this subject and are involved in a hearing, and Senator Lugar will not be able to be here until this afternoon. As ranking member of Agriculture he is deeply involved in that matter, and there is some real sort of dilemmas on the floor of the Senate right now that are, as they say, seizing the body in a way that has made this an uncertain start. This hearing was supposed to start at 10 a.m. We moved it up to 9:30 in order to get in, to accommodate, or to accommodate us.

Two of our witnesses, Dr. Meserve and Dr. Cobb, are unable to be here this afternoon. There is no reason why they should have been able to. They were told this was going to be in the morning in the first place, and Dr. Koonin, the Provost at California Institute of Technology in Pasadena is here. He was kind enough to be here this morning, and indicated he would be here this afternoon, and we will hear from Drs. Kelly, who is the president of the Federation of American Scientists, and Dr. Vantine, who is division leader of the Counter-terrorism and Incident Response at Lawrence

Livermore National Laboratory in Livermore, California, this afternoon.

I should state to the press that we had a closed hearing yesterday in S–407, a secure room, because quite frankly we are sort of—improvising is the wrong word, but deciding as we go that fine line between the public's right to know and need to know, and us not providing, as one person said, a cookbook for some screwball who, seeing this televised on national television, would be able to—or would think he or she would be able to cause some havoc.

I personally—and I have consulted with my colleagues, particularly Senator Lugar, on this—have little doubt that the terrorists we are most concerned about have knowledge of what we spoke about yesterday, but it still is a close call. I instructed the witnesses—that is the wrong word. I have suggested to the witnesses, I have instructed no one, that if any question that I ask this morning or this afternoon they believe would border on releasing information, although may be in the public domain but not so easy to access, that they think would be detrimental if broadcast, they should just indicate they would rather discuss that in a closed session.

Now, the second point I would make is, Senator Helms is unable to be here this morning. He is at the White House now, if I am not mistaken, I think on another matter unrelated to this, but hopefully will be here this afternoon.

I have a prepared statement that I am going to enter in the record to save time. I will just suggest the following, that I have long believed and felt, and on three occasions attempted to raise the concern, and I would suggest some degree of alarm, about the possibility of terrorists, and we have learned very clearly that terrorists are fully prepared, some to give their lives, in an effort to undertake their terrorist activity. That being the case, it raises the ante when we are talking about potentially more dangerous avenues of attack.

In particular, it means our assumption about radiological and nuclear weapons in the hands of al-Qaeda and other fanatic groups must be revisited and revised, and that we had thought that extremely radioactive sources were self-protecting in that they were difficult to handle, and people would be unwilling to handle them. We had thought that no terrorist would use them because his own death was guaranteed by exposure, from the radiation emitted.

We now know that is not true. Today there is a new reality. Today there is a new reality. Today we know that radiological and nuclear attacks in the United States are not only possible, but there are enough screwballs out there who are willing to risk their lives or give their lives in order to use them or other potential weapons against the United States. Today, we know such attacks would be terribly devastating.

We have come to realize that there are those who would literally die to use them. If a dirty bomb were to be detonated in the center of Washington, or if a highly radioactive can of powder were emptied from a rooftop, it could kill dozens. It would not be the catastrophic event that many think, but it would have a catastrophic psychological impact on the Nation and, even worse, it would contaminate a city that would probably result in evacuations and great

difficulty in convincing the American public that it could be reinhabited, even though the increased cause or risk of cancer and/or other negative health effects would be relatively minimal.

The economic impact that could result from such an attack could be devastating. We all know what the economic impact was when the World Trade Towers came down, beyond the impact of the loss of the towers, as well as the loss of the personnel and the businesses that were contained in the towers. It went beyond that, and quite frankly, I have tried, along with others on at least three occasions in the last year to raise the alarm bell about this.

I must be straightforward with you. This is not what the scientists are here to discuss, but I want to straightforwardly state what my purpose is as chairman of this committee in trying to highlight this danger again, and this will not be the last hearing I will have on this. I am going to do this until the policymakers in the Congress and in the White House and in every unit of government begin to make a decision about priorities in this country.

One of the things we have to look at as policymakers is what is the most likely devastation that could be rained upon the United States if we are willing, and I am not opposed to it in principle, if we are willing to commit to spend $100 billion—depending upon whether we have a layered national missile defense system or a single system that is limited, we are talking about spending, committing over the next 10 years somewhere between $100 billion to $1 trillion on national missile defense.

And I would love to have a national missile defense that was redundant, but the Pentagon, as well as many others, believe that is the least likely threat we face, is from an ICBM hurtling across the skies, crashing into the United States of America. It is a real threat. It is a possibility, but it is not the most likely possibility, and I would argue, and have argued for a long time, that even before the so-called Baker-Cutler report was issued, that the single most urgent threat we face is the access potential terrorists have to fissile material, and knowledge and access to scientific capability that resides in what I refer to as the candy store of all candy stores for terrorists, and that is Russia.

The good news is, Russia wants to cooperate. Russia needs help. Russia wants to inventory and wants us to help account for and destroy, or at least secure nuclear weapons and fissile material. The Baker report indicated that it was the most urgent national threat we faced, and that it would cost $30 billion over the next 5 to 8 years to begin to corral it, so I just want us to be facing head on and look realistically into the eye of the threat and make some realistic decisions based on priorities and limited resources after we have heard all the evidence, the point being, we have to wonder if terrorists could take advantage of a situation—for example, the curie conventional measure of a radioactive source, a tenth of a curie can kill people within a few weeks. A single curie is a very strong source and, if left unshielded in an office, could kill the inhabitants in days.

A cesium source found in North Carolina in a steel mill was only 2 curies in strength, but far more intense sources of radiation have turned up in some strange places lately. Last December, in the former Soviet Republic of Georgia, three hunters gathering fire-

wood stumbled upon two abandoned canisters, incredibly lethal material, which the canister contained 40,000 curies of material. By the way, all three hunters were critically injured, but since they did not break open the canisters, there was no environmental contamination.

Let me just say, even though a team from the Government of Georgia and the International Atomic Energy Agency recovered the containers, several more Soviet sources are unaccounted for. It is certainly not comforting to think the former Soviet Union made hundreds of similar devices.

These hearings are intended to let us know exactly what is out there and how close the threat of terrorists getting their hands on such material really is. We need to know what is possible, and how readily terrorists could make a dirty bomb. We also need to consider how terrorists might turn uranium or plutonium into a true nuclear explosive.

We need to know how, with or without explosive devices, nuclear materials might be dispersed and dispensed, and the kind of damage that could be done. We need to know what has to be done to ensure that the threat remains exactly that, a threat and nothing more. We once thought it would be virtually impossible for anyone to have the money, the means, the motive to build its own nuclear explosive device and the will to use it, but just last month, according to press reports, our Special Forces found pamphlets and manuals on nuclear weapons in al-Qaeda safe houses.

We learned of al-Qaeda's dealing on the black market for nuclear materials. Whether they have been successful is doubtful, but Time Magazine this week reported an alleged plot to bring a nuclear device to New York. September 11 vividly shows us the kind of hatred we face, the kind of people who, were they to get their hands on such weapons, would have no hesitation to kill Americans.

We have a new perspective, in many ways a more realistic perspective. We see the clear and present danger. We understand the threats that exist. We also understand that we must address these threats. Before we can be successful in protecting against them, we have to have a complete understanding of them. We have to know exactly what the terrorists can do with nuclear materials, from the simplest application to the most sophisticated, and there are important steps we can take to stop them, from improving nuclear security in the former Soviet Union to thinking carefully about our response here at home, to combating the threat of nuclear terrorism, and make it much less destructive if it were to occur.

Are there international conventions and codes of conduct which could restrict access to fissile material? Can the IAEA help? How can we allocate resources to combat radiological or nuclear terrorist attack? What priority should this have in the larger context of defending the United States, as compared, for example, to other defensive systems or buildings? What is required to protect against radioactive and nuclear terrorism, as compared to protecting against biological agents or chemical weapons in the hands of rogue states?

The bottom line, the choice would be made based upon what we know and what we think is most likely.

[The prepared statement of Senator Biden follows:]

PREPARED STATEMENT OF SENATOR JOSEPH R. BIDEN, JR.

I have long believed and felt—and have attempted to raise the alarm—about the risk of terrorism with weapons of mass destruction. September 11 introduced the possibility of terrorists prepared to give their lives in undertaking their activities. The ante is raised by that; we now face potentially more dangerous avenues of attack, such as the use of radiological weapons.

We had thought that extremely radioactive sources were "self-protecting." We had thought that no terrorist would use them because his own death was guaranteed by exposure to the radiation they emit.

We now know that's not true. Today there's a new reality. Today we know that radiological and nuclear attacks on the United States are not only possible, but there are enough screwballs out there willing to risk or even give their lives to use them against the United States.

We know such attacks would be terribly devastating. And today we realize that there are those who would literally die to use them.

If a dirty bomb were to be detonated in the center of Washington, or if a can of highly radioactive powder were emptied from a rooftop, it could kill dozens—it would not be the catastrophic event that many might think it would be, but it would have a catastrophic psychological effect on the United States. Even worse, it would so contaminate part of the city that we'd have to evacuate and perhaps demolish a number of buildings. The economic impact could be devastating.

One of the things we have to look at as policy makers is what is the most likely devastation that could be rained on the United States. Should we spend up to a hundred billion dollars to a quarter trillion dollars for a national missile defense system while the Pentagon, as well as many others, believes the least likely threat we face is from an ICBM missile? It is a real threat, it is a possibility, but it is not the most likely possibility.

I have argued for a long time that the single most urgent threat we face is the access that potential terrorists have to fissile material and knowledge and scientific capability that resides in what I refer to as the candy store for terrorists, and that is Russia.

The good news is Russia wants to cooperate, it wants to inventory and wants us to help account for and secure nuclear weapons and fissile material. I just want us to look realistically at the threat and to make some realistic decisions based on priorities and limited resources after we have heard all the evidence.

The curie is the conventional measure of the intensity of a radioactive source. A tenth of a curie can kill people in a few weeks; a single curie is a very strong source, and if left unshielded in an office could kill the inhabitants in days. The cesium source found recently in some scrap metal in a North Carolina steel mill was only two curies in strength. But far more intense sources of radiation have turned up in some strange places recently.

Last December, in the former Soviet Republic of Georgia, three hunters gathering firewood stumbled onto two abandoned canisters of an incredibly lethal material. Each of those canisters contained 40,000 curies of material.

By the way, all three hunters were critically injured, but, since they didn't break open the containers, there was no environmental contamination.

Let me just say, even though a team from the government of Georgia and the International Atomic Energy Agency recovered the containers, several more former-Soviet sources are apparently unaccounted for.

It is certainly not comforting to think that the former Soviet Union made hundreds of similar devices.

These hearings are intended to let us know what exactly is out there and how close the threat of terrorists getting their hands on such materials really is.

We need to know what's possible, how readily terrorists could make a dirty bomb. We also need to consider how terrorists might turn uranium or plutonium into a true nuclear explosive.

We need to know how, with or without explosive devices, nuclear materials might be dispersed and the kind of damage that could do.

We need to know what has to be done to ensure that the threat remains exactly that—a threat—and nothing more.

We once thought it would be virtually impossible for anyone to have the money, the means, and the motive to build his own nuclear explosive device, and the will to use it. But just last month, according to press reports, our Special Forces found pamphlets and manuals on nuclear weapons in al-Qaeda safe houses.

We've learned of al-Qaeda's dealings on the black market for nuclear materials.

Whether they've been successful is doubtful, but *Time* Magazine, this week, reported an alleged plot to bring a nuclear device into New York.

September 11 vividly showed us the kind of hatred we face, the kind of people who—were they to get their hands on such weapons—would have no hesitation to kill Americans.

We have a new perspective—in many ways, a more realistic perspective.

We see the clear and present danger and we understand the threats that exist. We also understand that we must address these threats. Before we can successfully protect against them, we have to have a complete understanding of them. We have to know exactly what a terrorists can do with nuclear materials, from the simplest application to the most sophisticated.

There are important steps we can take to stop them—from improving nuclear security in the former Soviet Union to thinking carefully about our response here at home—to combat the threat of nuclear terrorism or make it less destructive if it were to occur. Some questions to consider:

Are there international conventions and codes of conduct which could restrict access to fissile materials? Can the IAEA help? How should we allocate resources to combat a radiological or nuclear terrorist attack? What priority should this have in the larger context of defending the United States—as compared, for example, to other defensive systems we're building?

What is required to protect against radioactive and nuclear terrorism, as compared to protecting against biological agents, or chemical weapons, in the hands of rogue states or terrorists? The bottom line: What choices should we be making based on what we know and what is most likely?

Our first witness is Dr. Richard A. Meserve, Chairman of the Nuclear Regulatory Commission. He's a man with an unusual background: a Ph.D. in applied physics from Stanford University, and a J.D. from Harvard Law School. Chairman Meserve has focused on an enormous range of issues that arise at the intersection of law with science and technology, including environmental law, nuclear licensing, and nuclear non-proliferation.

Then we will hear from Dr. Donald D. Cobb, Associate Laboratory Director for Threat Reduction at Los Alamos National Laboratory. In his thirty-year career, Dr. Cobb has managed major programs in arms control, the detection of nuclear explosions, and the developments of safeguard systems.

Later, we will speak with Dr. Steven E. Koonin, who is a specialist in theoretical nuclear physics, Provost of the California Institute of Technology and chair of JASON, the group of top scientists who have advised the government on issues including nuclear weapons, arms control, and intelligence for almost four decades. In 1999 he was the recipient of the Department of Energy's prestigious E.O. Lawrence award.

He has studied possible radiological and nuclear terrorist devices, and, not surprisingly, found their potential extraordinarily alarming.

The Federation of American Scientists has long been an important voice to educate the nation about nuclear issues. We are pleased to have its president, Dr. Henry Kelly, here to discuss the recent FAS study of the effects of a dirty radiological bomb. Dr. Kelly spent over seven years as Assistant Director for Technology in the White House's Office of Science and Technology.

And finally, we will hear from Dr. Harry Vantine, Division Leader of the Counterterrorism and Incident Response Division at Lawrence Livermore National Laboratory.

[The prepared statement of Senator Helms follows:]

PREPARED STATEMENT OF SENATOR JESSE HELMS

RADIOLOGICAL DISPERSAL DEVICES: THREAT AND RESPONSE

Mr. Chairman, thank you for scheduling this hearing today.

As we have all learned so tragically, terrorist organizations present a very real threat to America and are capable of the most vicious and barbaric acts.

The increasing capabilities of terrorist groups and the malevolent intentions of those nations that support them combine to threaten us in ways not previously imagined.

Because these threats are only limited by a terrorist's ingenuity and capabilities, we must defend the American people against *all* potential threats.

Today we will hear testimony on Radiological Dispersal Devices, one of those threats known to only a few, but which could cause harm to many. These "dirty bombs," as they are more commonly known, combine conventional explosives with radioactive material.

These devices are often simple to build—if you have the necessary materials—but will likely produce more fear and terror in a civilian population than actual damage. That is why the potential threat must not be exaggerated.

To begin, the radioactive material needed to build these bombs is difficult to acquire, and even more difficult to handle or transport.

Additionally, in contradiction to published news reports, these devices are not likely to kill thousands of people, or to leave large swaths of land uninhabitable for decades.

Rather, scenarios envisioned by the intelligence community indicate that more people would be harmed by the bomb blast than from the radiation itself, which would most likely be less than what the average person receives in a year from the sun.

But while the physical destructive power of a radiological dispersal device may be very limited, its psychological impact on our economy and sense of security could be enormous.

In light of this potential catastrophe, the administration is sensibly advancing efforts to secure our borders, tighten our customs procedures, and strengthen export control laws. The administration is also bolstering multilateral export control regimes and the national initiatives abroad that support them.

Another integral aspect of our defense against this threat is our set of programs that account for and secure Russian nuclear material and prevent their potential theft or illicit transfer.

Such programs are undermined, however, when Moscow squanders U.S. assistance, fails to tighten its own export control and border security procedures, and continues its dangerous nuclear cooperation with Iran.

That is why my "debt for non-proliferation" legislation, which passed unanimously through this Committee last year, conditioned any debt relief for Russia on Moscow ending its illicit relationship with Tehran.

Russian nuclear proliferation to Iran is a clear threat to the United States, and its interests and allies in the Persian Gulf region, and must be stopped.

How the United States prepares to deal with the consequences of an attack employing a nuclear weapon or radiological device is an essential government responsibility; however, I would much prefer first to prevent and defend against the clear threat—Russian proliferation to Iran—rather than deal with the terrible consequences that could follow.

This is why, given Russia's equally nefarious proliferation of missile technology to Iran, I applaud the President's decision to withdraw from the outdated ABM Treaty and to build robust missile defenses.

In short, when it comes to America's security, we must be prepared to deal with threats.

I am grateful to our witnesses for being here today, and look forward to their testimony.

The CHAIRMAN. Our first witnesses this morning are going to be—and I am going to have to go a little out of order here, since we changed it—Dr. Donald D. Cobb, associate laboratory director for Threat Reduction at Los Alamos National Laboratory. In his 30-year career, Dr. Cobb has managed major programs and arms control, the detonation of nuclear explosions, and the development of safeguard systems.

We also are going to hear this morning from Dr. Richard A. Meserve, Chairman of the Nuclear Regulatory Commission [NRC]. He is a man with an unusual background, a Ph.D. in applied physics from Stanford University, a J.D. from Harvard Law School. Chairman Meserve has focused on the enormous range of issues that arise at the intersection of law and science and technology, including environmental law and nuclear licensing and nuclear nonproliferation.

We are also going to hear, time permitting—and he has been wonderful in accommodating us—Dr. Steven E. Koonin, who is a specialist in theoretical nuclear physics, the Provost at California Institute of Technology, in care of JASON, a group of top scientists

who have advised our Government on issues including nuclear weapons, arms control and intelligence for almost four decades.

In 1999, he was the recipient of the Department of Energy's prestigious E.O. Lawrence Award. He has studied possible radiological and nuclear terrorist devices and, not surprisingly, found the potential extremely alarming.

We also will hear later from Drs. Kelly, representing the Federation of American Scientists, and also from—I apologize for skipping around, but we have changed the order here. We are going to hear from Dr. Harry Vantine, division leader of the Counter-terrorism and Incident Response Division at Lawrence Livermore Laboratory.

Gentlemen, do you have a suggested way in which it is most orderly to proceed this morning? Should you begin, Dr. Meserve?

Dr. MESERVE. I would be happy to.

The CHAIRMAN. If you would proceed, and I thank you again for accommodating our hectic schedule.

STATEMENT OF DR. RICHARD A. MESERVE, CHAIRMAN, NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC

Dr. MESERVE. Mr. Chairman, I am very pleased to have the opportunity to meet with you today to discuss a very important subject. As you indicated, I am the Chairman of the Nuclear Regulatory Commission. Most of our attention, or a large part of our attention since September 11, as you will appreciate, has been focused on nuclear power plants and the hazards that might be associated with a terrorist attack on such a facility. The NRC also regulates radioactive materials, and they also have not lacked attention since the September 11 events.

What I would like to do this morning is to briefly cover three subjects. First, our assessment of radiological dispersion devices, which I will come back and define in a moment. Second, I would like to discuss some of the NRC actions to deal with the threats associated with such devices, and then finally I would like to briefly discuss materials associated with nuclear weapons themselves.

Let me first describe what I mean by a radiological dispersion device. This is a terminology that is used to describe any device that would serve to disperse radioactive material in a public area. For example, one might imagine that one could take some conventional explosive and to combine it with radioactive material and use the explosive as the vehicle to disperse the radioactive material in a public area. This, of course, has to be sharply distinguished from a nuclear weapon, which itself relies upon the nuclear material to cause the propulsive force. A nuclear weapon, of course, as you all know, would have devastating effects. This is in contrast with a radiological dispersion device. Our evaluation, consistent with the statement you made at the beginning, Mr. Chairman, is that such devices are really not very effective as a means for causing fatalities. We have looked at a range of scenarios in which they might be used, and they could cause, certainly could cause death, but we are talking deaths on the order of tens of people in most scenarios, rather than hundreds or thousands, or tens of thousands.

The reason for this is that the very large sources, some of which are in use to irradiate the mail that you are receiving, tend to be self-protecting in the sense that these very large sources would be

very difficult to handle without elaborate equipment. An individual has to be shielded in order to avoid health effects.

The CHAIRMAN. Can you explain what you mean by shielded, doctor?

Dr. MESERVE. By shielded we mean some material, for example, lead, which serves to attenuate or stop the radiation that is emitted from the device. If there is shielding between you and the device, then you do not get the radiation exposure.

The CHAIRMAN. Is it appropriate for those who are listening to think in terms of a shield like when you go in and have an x ray, and you have that big leaded apron put on you, that it prevents the radiation from penetrating that, and only goes to the area where it is intended?

Dr. MESERVE. That is exactly right. That is exactly what I mean.

The CHAIRMAN. Thank you.

Dr. MESERVE. These devices, very large sources, tend to be self-protecting, in that someone handling such a device, without handling them in an appropriate way, could get a lethal dose of radiation very quickly, in a matter of a few minutes or so, and would rapidly become very disorganized and unable to function, and would die soon.

The second reason why these sources tend not to have large health effects is that the dispersal of the radioactive material tends to reduce the risk, in that intensity of the source is reduced by spreading it over a larger area. Of course, if you have an explosive event, people are aware that something has happened, and they can be evacuated from the area, so you do not have an extended duration of exposure. The intensity of the radiation times the time in which you are exposed is what determines the risk.

So we do not see that radiological dispersion devices themselves, because of their radiological properties, have very significant health risk associated with them and, of course, that is the reason why no country of which I am aware includes such devices in its armories. Although there are countries that have contemplated biological or chemical or nuclear weapons, radiological dispersion devices are not included, and that is because they are not very effective as weapons.

This is not to deny the fact that they could have a very severe psychological effect, and that there is a fear of radiation, a fear of health effects. Of course the terrorists' greatest weapon is fear, and I think that one of the beneficial things that I hope will come out of this hearing is a process of educating the American public, as a part of our self-defense, that such devices are likely to have limited direct health effects.

Of course, a second consequence, as you noted in your opening statement, is the problem that these devices could spread contamination over an area that might not result in serious health consequences, but would have to be cleaned up. There would be the effect of people's concerns about that area in the future and clean-up costs would be expensive. The deflection of people from their normal activities until the area has been cleaned up is going to create costs. So I do not mean to minimize consequences of such an event, although the health effects are not particularly significant.

In light of the consequences, however, it is important that we have tight regulatory controls on these materials.

Let me say that nuclear materials are in widespread use in our economy, and the uses range from radiopharmaceuticals, to the radiography of welds in construction sites, to instruments that are commonly used in production processes in plants to measure the flow of materials, the level of materials in tanks and the like. Many of these materials that are in common use would not be attractive for a radiological dispersion device in any event, because they could only be available in small quantities and have a very short half-life.

Most radiopharmaceuticals, for example, have only a short half-life, so they would not be particularly useful for terrorist purposes. But nonetheless there are some of these materials that are of concern.

The NRC before September 11 had a comprehensive set of licensing requirements to ensure that radioactive materials are used, stored, and transported in a safe fashion. The focus of the regulatory requirements was on safe use. September 11 has awakened us to the concerns about possible malevolent use of these materials in a way that we had perhaps not appreciated as fully as we might have. The actions we have taken since then include the issuance of a series of advisories to our licensees.

Let me say many of these materials are regulated by the states, and so we work cooperatively with the states in this area. We issued advisories to our licensees and the states have issued parallel advisories to their licensees to basically bring these materials under tighter controls. This is not the forum in which to go into the details of all of these requirements, but they basically involve increased attention to unusual activities that might be associated with these materials, tighter security controls, increased protection of the materials, making sure, if there are unusual activities, that there are reports to the police and to us about these events so they could be evaluated for intelligence purposes, and increased scrutiny of who is purchasing materials.

We are also undertaking a comprehensive examination of our regulatory system. We work in this area with the Office of Homeland Security, the FBI, the Department of Energy and the Department of Transportation, Customs Service, and with the states, as I have indicated. All of us have some piece of this puzzle, and we are working this issue. As a result of the comprehensive review I expect there will be some tightened, more permanent regulatory changes that we will be making.

I would like to close by saying just a few words about special nuclear material. These are the materials that are the essential ingredients in building a nuclear weapon. As I have indicated, such weapons should be sharply distinguished from radiological dispersion devices because of the consequences that would be associated with their use. An essential ingredient in a nuclear weapon is special nuclear material—that is, highly enriched uranium or plutonium.

We have extensive safeguards in this country on such material, and have had for 50 years, in recognition of its importance. Such materials are very heavily guarded at all times, with extensive

monitoring devices and other aids to assure that this material does not escape from control.

As you indicated in your opening statement, the crucial issue with regard to these materials is the possibility they might be diverted from a foreign source. There are huge quantities of such material in Russia under limited control. There have been extensive programs that have been undertaken by the Department of Energy in particular to try to bring these materials under control, but there is still a lot of work that will have to be undertaken.

I share your view that this is an important challenge in which the United States should be engaged in order to assure the protection of such materials at the source, because if they were to be lost from their source, they would be very hard to detect. I think this is a national priority to build on the programs, that incidentally have had bipartisan support over the years, to assure that these materials are safeguarded adequately.

That concludes my statement. I would be very happy to respond to questions.

The CHAIRMAN. Thank you, doctor. I think what we should do is hear from all the witnesses, if we could, and Dr. Cobb, we welcome you, and again thank you not only for this morning, but for yesterday. My colleagues and I found your briefing thorough and interesting and chilling, and somewhat hopeful.

STATEMENT OF DR. DONALD D. COBB, ASSOCIATE LABORATORY DIRECTOR FOR THREAT REDUCTION, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM

Dr. COBB. Thank you, Mr. Chairman, for inviting me to discuss this important topic of potential terrorist attacks not only using radiological dispersal devices, but the entire spectrum of potential nuclear terrorism threats that we face. You mentioned, as the Associate Director for Threat Reduction, I have been working some of these issues for 30 years. I have a written statement that I have submitted. I would like to just make a few points.

The CHAIRMAN. Your entire statement will be placed in the record.

Dr. COBB. Thank you, sir.

Briefly, let me start by saying—and I think you pointed this out in your opening remarks—that we cannot just focus on part of the problem. It is not just radiological dispersal devices. The entire spectrum, from that perhaps being the low end of terrorism, to now concerns about nuclear ability to acquire the materials and create a nuclear explosive device. I think we need to consider all of these in the context of the concerns we have today.

Let me just say for the past 30 years we have been looking for evidence of not only countries acquiring nuclear materials, but other groups that might be supported to acquire those, so it is not a new thing we are worried about the threat, but since September 11, clearly it has brought home the desire to create and inflict the maximum amount of damage by the terrorists to our country, so I think that did change on September 11, as has changed our viewpoint.

The CHAIRMAN. And if I might interject, I do not know if this is true, but I think since the Wall came down and the Soviet Union

broke up, we have a very different view of, at least in my recollection, dealing with this subject for years and years, particularly on the strategic doctrine side of the equation was that we did not worry very much about the lack of control of this material in weapons by the former Soviet Union. We, as a matter of fact, ascribed to them a capability and a security apparatus that was tighter than it really was, but after the wall came down and the Soviet Union broke up, I would suggest that put a slightly new slant on our concern.

Dr. COBB. That is exactly right, sir, and in fact as you know, prior to the fall of the former Soviet Union, the KGB and tight security enforcement in Russia and control of the people were the methods to control these, and it made us less concerned, but since that time, of course, opening up the Soviet Union has made a difference, and let me say some more words about that as we go through, because I think that is an essential point.

One of the principles in relating to nuclear materials and the nuclear threat that goes back to Manhattan Project, and I think Dr. Meserve mentioned this, is to control the materials, keep the sources of these materials out of the hands of the bad guys.

The CHAIRMAN. For the public, would you explain the materials you are referring to?

Dr. COBB. The materials are nuclear materials that are source materials that could be used, for example, in nuclear weapons. For nuclear weapons it is enriched uranium and plutonium, and so for 50 years the focus has been to keep the use of those types of nuclear materials rigidly controlled so that they do not get diverted and get distributed. I think we can extend some of that principle to radiological materials, and I think Dr. Meserve talked about a change in emphasis toward helping to control the materials.

Let me talk to you about a couple of the programs that I think are important that we can draw on, because I think some of the things that we have done over the last 10 years since the fall of the Soviet Union can apply here. One of them is, and again the Department of Energy, the National Nuclear Security Administration has been working the materials protection, control, and accounting, and what that is basically is to work with colleagues in Russia at sites, and there are over 100 of them, to try to secure the nuclear materials that they have, the materials that are weapons-usable materials, and that is what we call kind of the first line of defense, securing the materials in place where they are so they cannot get out.

Once they get out, they are much more difficult to find and track, so that is one. If you worry about, and you do, if you worry about the materials that could be smuggled across borders, at transit points, overseas, out of Russia, maybe through intermediaries in Europe and other countries, then getting into the United States, you need border protection, so securing—and let me say today we do not have the security at the borders we would like to have, but the ability to develop detection capabilities to look for nuclear materials.

If I talk about weapons-usable materials—let me be clear, if I am talking about enriched uranium or plutonium, those are very challenging things to detect at those points, so that is a focus for us

to develop that capability, and has been. If you think about these radiological materials, particularly if you are talking about large sources of the type that you mentioned in your opening statement that might be used overseas, those also generate a lot of radiation that is detectable by the sensors, and so in some sense for free we get some capability if we just deploy the systems we are talking about today at these borders and choke points, looking for all of the materials, including radiological, so that is a second one.

A third one that I would cite is, we have international agreements. We have the International Atomic Energy Agency [IAEA], which has the safeguards program. We have a Nuclear Suppliers Group, which looks at export controls. What that means is that we actually share information with over 30 other countries about nuclear-related exports, technologies, materials, whatever it might be. It seems to me reasonable to just kind of expand that even on an informal basis to share information about radiological materials as well as nuclear weapons-related technologies and materials.

So there are a number of things that are already available, kind of institutionalized, that we can draw on to extend to the radiological problem, and I personally believe that we should, and I would say for the National Nuclear Security Administration [NNSA], the Department of Energy, they are talking—you mentioned the Russians are being cooperative. Well, I know the people in DOE are talking to their Russian counterparts about extending some of these programs.

Let me go on to say that there is a difference, though, between the radiological sources, the sources of mass disruption, as people have called them, versus nuclear weapons-capable materials, and I think Dr. Meserve did a good job of talking about them. They are distributed widely. There is a problem that the materials that could be radiological sources could be susceptible to theft or diversion, even locally in the United States, be closer at hand so there is a possibility that they could be stolen. Clearly, that is a licensing and control issue that needs work, and Dr. Meserve I think addressed that very well.

Let me talk about one point that is related to what happens, what are we going to do about it if something does occur? Clearly, the state and local first responders, the state and local agencies are going to be faced with this, and so today the Federal Government, the Department of Energy, we are working with state and local responders, we are doing exercises and training, and I think we need to do more of those kinds of activities.

If the worst does occur, it is a nuclear emergency support team, the Federal-level Department of Energy people that will be the Federal help in response to such an activity to actually understand what the extent of the damage is, what kind of responses would be most effective to preserve human life, protect the health of the public, and protect the environment.

The nuclear emergency support team is mostly configured with people from the national laboratories who are experts in radiation and detection, and all of these various technologies, and they are volunteers, and I just wanted to say we are very proud of them, because these people, they give up nights, weekends, they are called out at any time of the day or night. They go off on short no-

tice to help with this, and so we are proud of that capability, but it needs to be expanded. It needs to be extended in terms of its capabilities to support the state and local authorities, particularly in consequence management.

What I mean by that, if there is a radiological dispersal, how do we deal with the cleanup problem? How do we protect the environment and the public? That is still a challenge, still something we need to work on with more training, more technology.

The final point that I want to make, our military is the best in the world, because we have our entire Nation's science and tech base supporting it. We need to apply that same kind of process for science and technology support to homeland security. I think we are starting in that direction. Since September 11 we are doing more, but that is the direction we need to do. We need better technology. We need better engagement of the science and technology providers to address these problems.

So again, thank you for inviting me.

[The prepared statement of Dr. Cobb follows:]

PREPARED STATEMENT OF DR. DONALD D. COBB, ASSOCIATE DIRECTOR FOR THREAT REDUCTION, LOS ALAMOS NATIONAL LABORATORY

Thank you Mr. Chairman and distinguished members of the Senate Committee on Foreign Relations for inviting me here today to discuss the very important problem of potential terrorist attacks using radiological dispersal devices (RDDs), so-called "dirty bombs."

I am Don Cobb, Associate Director for Threat Reduction at Los Alamos National Laboratory. I am responsible for all programs at Los Alamos directed at reducing threats posed by weapons of mass destruction—nuclear, chemical, biological. I personally have more than 30 years experience working to reduce these threats.

Let me begin by saying that one needs to consider the RDD threat in the broader context of threats posed by nuclear terrorism and, in turn, in the even broader context of all types of potential terrorism against the United States and our allies. The events of September 11 show clearly that terrorists want to inflict as much damage as possible on our institutions and thereby strike at our core values.

The spectrum of nuclear terrorist threats—starting with RDDs at the low end of the spectrum of violence and moving up through improvised nuclear explosives or stolen nuclear weapons is a fearsome challenge. We must consider these together in the context of the terrorist's intention to inflict maximum damage.

Unfortunately, there is no silver bullet that will protect us from these threats. Rather we must have a systematic approach that provides us with defense in depth. The good news is that a systematic approach is possible against the spectrum of nuclear terrorist threats, but it will take much hard work and continued investments to achieve. And of course there is ultimately no foolproof system against all possible threats. But the beginnings of such a system against the most pernicious threats is starting to emerge after a decade of effort starting with the Nunn-Lugar program.

Allow me to illustrate what I mean by a few examples. We have been working with the Russians for several years now to secure nuclear weapons and materials through the National Nuclear Security Administration's Materials Protection, Control, and Accounting Program. Experts generally believe that the nuclear weapons in Russia are more secure than the nuclear materials. In any case there are hundreds of tons more weapons-usable materials scattered at sites across the former Soviet Union not in weapons than there are materials in weapons. Of course we can't ignore the security of the weapons, but the materials are perhaps the greater danger. The Baker-Cutler report calls this, "the most urgent unmet national security threat to the United States."

It seems logical to ask, can we extend the MPC&A program to cover radiological sources as well as weapon-usable materials? It is these sources that are least well protected, and have a special concern for RDDs. The answer appears to be yes. At least the NNSA officials responsible for the MPC&A program are working with their Russian counterparts to move in this direction.

Another NNSA program, called the Second Line of Defense (MPC&A being the first line), is working to establish detection systems at borders and transit points in Russia and the former Soviet countries to detect smuggled nuclear material.

While the focus is on weapon-usable materials, these same systems with some modest modifications would also be effective against smuggled radiological sources, since the radiation signatures from such sources is generally much stronger than from uranium and plutonium.

There are some major differences however. Nuclear weapons and weapon-usable materials tend to be focused in military applications under tight government oversight. There are international agreements and arrangements governing the authorized export and use of such materials. Radiological sources are more wide spread and have fewer controls. For example, there is not an export control regime for such sources comparable to the Nuclear Suppliers' Group for weapon-usable materials. It seems logical to use and extend these existing arrangements to at least the notification of intent to export large radiological sources.

What is in effect the third line of defense consists of efforts to detect and intercept smuggled nuclear materials at U.S. borders and entry points. Most U.S. customs agents and emergency response teams in large cities have hand-held radiation sensors that can detect large radiological sources generally more easily than weapon-usable materials. But better technology is needed to detect and intercept nuclear materials, including radiological sources, concealed in luggage, packages, or shipping containers.

Perhaps the biggest difference between nuclear weapons and weapon-usable materials and radiological sources is the possibility of a terrorist obtaining radiological sources "at hand", rather than having to smuggle them into the United States. In the U.S., nuclear weapons and weapon-usable nuclear materials are under extremely tight security. Radiological sources, on the other hand, are more susceptible to theft or diversion, possibly by insiders.

If the worst occurs, whether it is a terrorist attack involving an improvised nuclear explosive device using weapon material or an RDD using radiological material, it will be up to the emergency response forces to deal with the consequences. In the U.S. the NNSA's Nuclear Emergency Search Team (NEST) is the group that would be called upon in case of a nuclear-related terrorist attack. NEST actually consists of multiple capabilities ranging from searching for a nuclear device to protection of people and the environment from radiological harm whether the cause is accidental or deliberate. The men and women of NEST largely consist of volunteer experts from the national labs. We're proud of them.

But more capability is needed considering the urgency of the threat post-September 11. We need more practice and training against realistic terrorist scenarios including RDDs. Clean up and wide-area radiological decontamination represent a huge challenge. We need to make investments in related science and technology now. We also need to upgrade our existing forensics and attribution capabilities against a heightened threat of nuclear terrorism.

The Defense Science Board studies of 1997 and 2000 made similar recommendations regarding state-sponsored or trans-national nuclear terrorism. Since September 11 some of these recommendations have begun to be implemented. But the pace remains slow and the scope of the effort is not yet broad enough to cover the spectrum of nuclear threats, including RDDs. This work needs to be expanded and accelerated now.

Finally I would like to point out that implementing these response measures just in the U.S. is not enough. We need to work to make sure that other countries have them as well, and Russia should be at the top of the list. The ability to locate and recover stolen nuclear materials, including weapon-usable or radiological sources, before they get out of the country should be a top priority. Notification that such a theft has occurred should also be a first priority. A Russia "NEST program" would be in our mutual interest. We should work to add this to the current list of successful cooperative programs, while we examine all of these programs from the perspective of their ability to counter the RDD threat.

Thank you.

The CHAIRMAN. Thank you. Actually, Dr. Koonin, maybe in light of the fact that you are fortunately here, and I may call on you again if I may, but maybe you should go forward with your presentation as well.

STATEMENT OF DR. STEVEN E. KOONIN, PROVOST, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CA

Dr. KOONIN. Mr. Chairman, my name is Steven E. Koonin, and today I want to discuss with you the threat of radiological ter-

rorism. Before I do so, however, I would like to place my remarks in a broader context. The events of last fall have induced all of us to pay greater attention to the safety and defense of the civilian population in this country. Unfortunately, this is a very difficult problem, because the number of targets that a terrorist might go after is virtually unlimited, and the resources that we have available to defend them are finite. We are going to have to be making hard choices about what, and what not, to protect, and about what to protect against.

Of course, not all threats are equal. The variables include the direct and indirect consequences of an attack, the likelihood of an attack, the vulnerability of the target, intelligence and warnings that we may have about the capabilities and intentions of an attacker, and the availability of plausible countermeasures.

I applaud the initiative of you and this committee in defining and addressing these very important issues. In that context, I want to call your attention to one type of terrorist attack that I believe is a very serious threat, the deliberate dispersal of radioactive materials. These materials might be the weapons-grade materials that Dr. Meserve and Dr. Cobb have talked about—the uranium and plutonium that make up a nuclear weapon—or they might be ordinary radioactive sources, cobalt, cesium, iridium, and so on, that find many uses in society.

The methods of dispersal could be explosive. We could be talking about the fallout from a successful or fizzled nuclear device, or they could be conventional, the so-called dirty bomb, in which conventional explosives are laced with radioactive material, or the dispersal could be covert, in which the radioactive material is contained in particles, aerosols, or perhaps in contaminated materials such as food.

The intent of the terrorists may be severalfold. They might be intent on inducing casualties, perhaps immediately as the result of radiation sickness, or longer term, as the result of cancers that might be induced by radiation exposure. But more likely they are going to be after the psychosocial reactions that are associated with radiation. These are certainly likely to be far more widespread and significant than immediate or long-term casualties.

In any case, a large-scale release of radioactive material could well entail significant costs, both directly in terms of cleanup expenses, and indirectly in terms of the economic disruption it induces.

What I am going to describe for you in the next few minutes are the potential threat, as I see it, and some of the possible steps that could be taken to reduce it. You have already discussed my credentials. I think I will just skip over that, other than to say that I have been involved in national security matters for more than 15 years. My expertise is in nuclear physics, and more recently I have been involved in counterterrorism studies, both biological and chemical, as well as thinking about nuclear-related matters.

It is true that radioactive materials find many uses in society, and so are quite common. They are indispensable for certain medical diagnostics and therapies. Perhaps less well-known is that intense radioactive sources are used to sterilize food and medical instruments. Sources are also used in industrial radiography: to

image equipment, and also, as Dr. Meserve mentioned, in the logging of oil wells. In addition, far less potent amounts of radioactivity are present in smoke detectors, antistatic devices, and exit signs. Many of these sources are harmless, and have no potential for terrorist misuse. There is also, of course, a significant amount of radioactivity contained in the spent fuel of the cooling ponds of the nuclear reactors that are about in our country.

I have some images here that illustrate, for example, a radiography, a bone scan that was taken using a technetium source, and one can see in the pictures the infected area in this particular patient. Also shown in the upper right is an antistatic brush with a polonium source that is used in darkrooms, and in the lower right is one of the cooling ponds around a reactor.

Even small amounts of radioactive material can be very disruptive. The sources of concern of long-lived isotopes range from 1 curie up to thousands of curies. If one were to take just 3 curies of an appropriate isotope, which is an amount that is a fraction of a gram, and disperse that over a square mile——

The CHAIRMAN. Would you give me an idea what that is? Is that as big as the head of a needle, or this pen?

Dr. KOONIN. A gram is about a thirtieth of an ounce, so it is perhaps the size of a ball on a ballpoint pen or something like that.

The CHAIRMAN. Thank you.

Dr. KOONIN. That amount of material would have to be diluted, of course. If it were spread over a square mile, that would make the area uninhabitable, according to the maximum dose currently recommended for the general population.

It is important to note, however, that the health effects of such contamination would be minimal. For every 100,000 people exposed to that level of radiation, four lifetime cancers would be induced, which would take place on top of the 20,000 cancers already expected to arise from other causes.

The CHAIRMAN. It is important that that gets straightened out. Without exposure to this 1 curie you just referenced, 20,000 people out of 100,000 today, without any additional exposure, are likely to get cancer. This would increase that by four?

Dr. KOONIN. That is correct, four out of 20,000.

The CHAIRMAN. So that is what you mean by the health effects would not be—it would be consequential for those four people, but it is not consequential in broad terms.

Dr. KOONIN. Of course. Of course, higher levels of contamination would——

The CHAIRMAN. The higher level of contamination, I understand your point. I just wanted to make sure everybody gets this.

Dr. KOONIN. However, the psychosocial effects of such contamination would be maximal, as we know from Three Mile Island, Chernobyl, and other incidents. Radiation taps into a very deep fear and concern that people have. There are tens of thousands of significant sources of this size in the United States, and many more abroad. Here is a picture of one, to just give you a sense of the size. This is a 150-curie source that is used in industrial applications, and it weighs 53 pounds. All of that weight is shielding. It is a compact 6 inches by 6 inches by 15 inches.

The CHAIRMAN. And that is a device legally used?

Dr. KOONIN. That is correct.

The CHAIRMAN. By shielding, you mean the lead that keeps this radioactive material from emanating from anywhere, other than when it is aimed and used for its purpose?

Dr. KOONIN. When the source is exposed, there is a mechanism in the box for exposing the source and, of course covering it up again.

The CHAIRMAN. Thank you.

Dr. KOONIN. In my view, radiological terrorism is a very plausible threat. Here are some facts that summarize the situation for me. Gram-for-gram, radioactive material can be as disruptive as weaponized anthrax, not necessarily as dangerous, but as disruptive. Furthermore, this material circulates broadly through society. We produce it. It can be purchased with appropriate licenses, at low levels without a license. We ship it, we store it, we have mechanisms for disposing of it, and so on. So it is out there.

Moreover, the expertise for handling it is widely known and readily acquired. In fact, you can take radiation safety courses from any number of commercial or nonprofit providers that teach you how to handle radioactive material safely.

As Dr. Meserve emphasized, the safety and security of radioactive material depends upon the good faith and good sense of licensed end users. The Nuclear Regulatory Commission does the licensing. Inspections of the sources onsite are sporadic, in my understanding. This system was developed at a time when we were facing a cooperative or nonhostile environment. The situation post 9/11 has changed significantly. This array of facts does not leave me with a great deal of comfort.

To make the threat a little more tangible, it is interesting to outline what a radiological attack might look like. You can imagine that a several-curie source was stolen, and that the source is dispersed covertly one night throughout the business district of a major city. There is then an anonymous tip the next morning, and officials detect widespread contamination at roughly three times the natural background level, which is well above the legal limit protecting the general population. They find this contamination over some 100 blocks of the business district. The area would be evacuated immediately and sealed off, and we could expect that hundreds of thousands of people would be showing up at hospitals demanding to be screened for contamination.

There would be, at this level of exposure, no fatalities from the radiation at all. However, the decontamination would take months. It is possible that buildings could not be economically decontaminated, and so dozens of them would have to be razed. In any event, there would be billions of dollars of economic damage.

In thinking through this sort of scenario, it is interesting that dose limits play a major role. Currently, there is a very low legal dose limit that properly protects the general public in ordinary circumstances, but in some ways this dose limit works against us in this situation. It makes it possible to do great damage, both psychosocial and economic, with very small amounts of contamination.

Further, the question of "how clean, at what cost, and when?" will inevitably have to be answered after any release. Given the

discomfort that is evident in many public discussions of radiation, this is going to be a very difficult discussion.

So what should be done? Let me offer a few high-level suggestions. One is to encourage alternative sources of radiation that can be turned off. There are accelerators, electrically driven neutron generators under development, and other devices that can substitute for radioactive materials in some circumstances, and there are regulatory, economic, and technological ways in which one might encourage those substitutions.

Second, as has already been mentioned, it is very important that we strengthen controls on radioactive materials. Some infrastructure is already in place domestically in terms of the Nuclear Regulatory Commission, and internationally in terms of the IAEA.

It is also very important for us to establish pathways that allow the retrieval, storage, and disposal of unwanted material. Currently, users have a very difficult time disposing of radioactive material.

I believe it is also important that we think about tracking personnel with radiation expertise. These people would provide a pool of expertise in the event of a response, and a database of people who understand how to handle radiation may help provide indicators of terrorist preparations.

Going further, we can think about the widespread deployment of radiation monitoring for the transport of large sources. Points of entry, choke points, luggage, and mail are all streams of material that should be routinely scanned for radiation sources.

It is also possible to think about distributed sensor arrays. The technology to detect radiation is well-known, unlike that for biological or chemical agents. It is robust, relatively inexpensive, and one could well imagine deploying sensors more broadly throughout society than we do currently. Whatever sensor systems are put into place, it is very important that they be significantly tested and "red-teamed" if they are to continue to be effective.

It is also, finally, important to educate and prepare the first responders and the public for the possibility of a radiological event. Again, this will likely not be simple, given the difficulty we have in talking about radiation.

Let me, then, summarize. The dispersal of radioactive materials is, in my opinion, a plausible and significant threat. However, it is overwhelmingly likely that the effects of a terrorist attack using radioactive materials will be psychosocial and economic, not entailing a large number of deaths or illnesses, and there are steps that can be taken to prevent such acts.

The first line of defense, as has already been mentioned, is the control of radioactive materials.

Thank you.

[The prepared statement of Dr. Koonin follows:]

PREPARED STATEMENT OF DR. STEVEN E. KOONIN, PROVOST, CALIFORNIA INSTITUTE OF TECHNOLOGY

Mr. Chairman and members of the committee. My name is Steven E. Koonin and today I want to discuss with you the threat of radiological terrorism.

Before I do so, however, I'd like to place my remarks in a broader context. The events of last fall have induced us all to give greater attention to the safety and defense of the civilian population. Unfortunately, this is a very difficult problem. Be-

cause the number of targets is virtually unlimited and the resources available to protect them are necessarily finite, hard choices have to be made about *what,* and *what not,* to protect, as well as what to protect *against.*

Of course, not all threats are equal. In allocating defensive resources, the factors to consider include the direct and indirect consequences of a successful attack, the likelihood of an attack, the vulnerability of the target, intelligence and warnings of potential attacks, and the availability of effective defense measures. I applaud the initiative of this Committee in defining and addressing these very important issues.

In that context, I want to call to your attention one type of terrorist attack that I believe to be a very serious threat: the deliberate dispersal of radioactive materials. These materials might be the weapons-grade metals used in nuclear weapons or the more common materials contained in radiation sources. The dispersal can be accomplished either through an explosive release (a nuclear device producing "fallout" or a conventional explosive that has been laced with nuclear material) or through a covert, and perhaps gradual, release of particulates, aerosols, or contaminated materials such as food. While the intent of the perpetrators might be to induce immediate or long-term casualties, far more widespread will be the intense psychosocial reactions associated with radiation. In any case, a large-scale release of radioactive material could well entail significant costs through both direct clean-up expenses and the economic disruption induced. My goal here is to describe for you the potential threat that I see and offer some possible steps that could be taken to reduce it.

My scientific credentials for this task are as follows. I am Professor of Theoretical Physics at the California Institute of Technology, as well as that institute's Provost. For more than 30 years, the focus of my teaching and research has been in nuclear physics and I am the author of some 200 referred scientific publications in that field. I have also served as the Chair of the Division of Nuclear Physics of the American Physical Society. Beyond my academic credentials, I have been involved in National Security matters for more than 15 years. I currently chair the JASON group of academic scientists and engineers, which has a 40-year record of unbiased technical advice to the government on national security matters. I have also served on both the Pentagon's Defense Science Board and the Navy's CNO Executive Panel, and also chair the University of California's committee overseeing the national security aspects of the Los Alamos and Lawrence Livermore National Laboratories. More specifically related to counter-terrorism, I led a DARPA-chartered JASON study of Civilian Biodefense issues in 1999, and served this Fall on Defense Science Board panel looking broadly at terrorism vulnerabilities. While my testimony is informed by these experiences, particularly discussions with my JASON colleagues, the words and opinions expressed are my own.

Radioactive materials are common in society. Their importance in medical diagnostic and therapeutic procedures is well-known. Less well known, but equally important, is the use of intense radioactive sources to sterilize food and medical instruments and to image industrial equipment (including the logging of oil wells). Far less potent amounts of radioactive materials are used in smoke detectors, anti-static devices, and self-illuminating exit signs. Many of these sources are harmless and have no potential for terrorist misuse. There is also a very large amount of radioactivity contained in the spent fuel in the cooling ponds at nuclear power reactors.

Sources ranging from a few to thousands of curies could be employed for terrorist purposes. If just three curies (a fraction of a gram) of an appropriate isotope were spread over a square mile, the area would be uninhabitable according to the recommended exposure limits protecting the general population. While direct health effects would be minimal (for each 100,000 people exposed, some 4 cancer deaths would eventually be added to the 20,000 lifetime cancers that would have occurred otherwise) the psychosocial effects would be enormous.

I believe that radiological terrorism is a plausible threat. Gram for gram, radioactive material can be at least as *disruptive* as weaponized anthrax. Further, the material circulates broadly through society. There are tens of thousands of significant, long-lived sources in the U.S. and many more abroad; they are produced, purchased, stored, and transported through ordinary channels. The expertise to handle them is widespread and/or readily acquired (radiation safety courses are offered regularly; you can sign up on the web), And the safety and security of these materials relies on the good faith and good sense of the end-users, who are licensed by the Nuclear Regulatory Commission. This array of facts does not leave me with a great deal of comfort.

One scenario of how a terrorist attack using radioactive material might play out is as follows. A several-curie source of a long-lived isotope is stolen and covertly released one evening throughout the business district of a major city. Acting on an anonymous tip the next morning, officials verify widespread contamination over a

100 block area at roughly three times the natural background level, well above the legal exposure limit protecting the general population. That area is immediately evacuated and sealed off as hundreds of thousands of people rush to hospitals demanding to be screened. Businesses in the area are shutdown during the many months of decontamination that follow; dozens of buildings are razed. Economic damage runs into the billions of dollars, but there are no direct fatalities.

Most important in thinking through the situation are the widespread fear of radiation and the low legal dose limits protecting the general population. These latter make the terrorists' task easier in at least two respects. First, even very low levels of contamination, comparable to the natural background level in many locales, will be very disruptive. Second, in decontaminating any site, the question of "How clean, at what cost, and in what time?" will eventually have to be answered; that will not be easy.

There are several kinds of measures that can be taken to prevent terrorist attacks using radioactive materials, or at least make them more difficult to carry out. Through various economic, regulatory, and technological mechanisms, one can encourage migration of legitimate users from radioactive sources to radiation sources that can be turned off, such as accelerators and electrically-driven neutron generators. However, this will not be possible for all applications. Strengthened controls on radioactive materials are therefore an important step; fortunately, some of the infrastructure is already in place through the NRC and the IAEA. Also important would be the establishment of pathways to retrieve, store, and dispose of unwanted radioactive materials. The tracking of personnel with radiation expertise also seems a good idea, as this would provide both a registry of trained responders in the event of an incident, as well as be of assistance in detecting terrorist preparations.

Widespread radiation monitoring to detect large sources as they are moved about would be very useful. One would start with ports of entry, transportation chokepoints, rail, plane, and ship cargo, and mail. Going further, it is not difficult to imagine widely deployed radiation detectors ("one on every lamp post"). In contrast to detectors for biological and chemical agents, the monitoring technology is well-established, the power and maintenance requirements are likely to be minimal, and the specificity and robustness will be high. Whatever the character and extent of radiation monitoring, it will be important to significantly test and "red-team" the system.

Before an incident occurs, it is important to educate the first responders and the public as to the nature of this threat, the probable consequences an incident (*i.e.,* few casualties, maximal disruption), and how they can be managed. This will likely not be simple given the unease evident in many public discussions of radiation.

In summary, I believe that the deliberate dispersal of radioactive materials is a significant and plausible threat. However, it is very likely that the predominant effects will not be casualties, but rather psychosocial consequences and economic disruption. Fortunately, there are a number of steps that can be taken to reduce the likelihood and impact of such an attack, beginning with the strengthening of controls on radioactive materials.

The CHAIRMAN. Thank you very much. I have a number of questions, and with your permission I may ask that we not overburden you, that we may be able to submit some questions in writing to you if that is appropriate. That is, if you agree.

Let me begin with you, Dr. Cobb, and you have all made—and it is important, I guess, I continue to make the distinction between a radiological device dispensing radioactive material in one form or another, and an improvised nuclear device. People talk about a bomb. The way it is thought about in the popular culture in the last couple of months is that there is a conventional explosive, radioactive material around that, the bomb goes off, the curies are dispersed throughout an area, depending upon how much radioactive material there is. There is a relationship between the intensity, the amount of the radiation that someone is exposed to and the duration of the radiation, is that correct?

Dr. COBB. That is correct.

The CHAIRMAN. And there is a second device, and the second device is an actual nuclear explosion, where you have weapons-grade

material, plutonium-enriched uranium, and either through a gun mechanism or some other mechanism they are at high speed pushed together, they cause a reaction, that reaction is explosive, that reaction has three features to it. One, there is a big blast, depending on the size of that weapon, a single kiloton or megaton—I mean, it depends upon the size, and that relates to the amount of material, correct?

Dr. COBB. That is correct.

The CHAIRMAN. And it has three effects. One, there is a blast. For example, we discussed yesterday if the similar amount of energy—we will have this testimony this afternoon. If a similar amount of energy that was released when the World Trade Towers came down as a consequence of the explosion that took place because of the jet fuel, if a similar amount were to take place with a nuclear device, instead of that building taking sometime to come down, it would be down in a matter of——

Dr. COBB. Virtually instantaneously. We are talking about 140 tons of high explosive equivalent being released in one moment.

The CHAIRMAN. So it would come down immediately?

Dr. COBB. Very quickly.

The CHAIRMAN. A second effect is, there is actual radiation released.

Dr. COBB. Right.

The CHAIRMAN. That is in relatively high doses, in high doses that if people are in that area they have ill effects, and the third is fire. There is a high intensity heat, and so you have buildings burning. You have fire, in layman's terms, is that correct?

Dr. COBB. That is correct.

The CHAIRMAN. Now, there is a phrase that—I thought I knew a fair amount about this, all the years doing arms control issues and the like. I had not until recently heard the abbreviation. All of the national security kinds of issues all have acronyms, and I had not heard of, I think you referred to it as an improvised nuclear device, an IND. Is that what you refer to it as?

Dr. COBB. That is correct.

The CHAIRMAN. So people are going to begin to hear about IND's, improvised nuclear devices.

Now, Dr. Harold Agnew, the former director of Los Alamos Laboratory said, "for those who say that building a nuclear weapon is easy, they are very wrong, but those who say that building a crude device is very difficult are even more wrong." Now, I am quoting him. Recent reports about a possible 10 kiloton nuclear weapon being smuggled into Manhattan last fall thankfully proved to be false, but I do not think anyone would suggest we should be complacent. As President Bush reportedly declared, nuclear terrorism in fact is the most serious danger to the U.S. national security today, and so what I would like to discuss for just a moment, what are the primary barriers facing an outfit like al-Qaeda, or other terrorist groups in seeking to acquire or construct an improvised nuclear device?

Dr. COBB. The answer is clearly controlling the nuclear weapon-capable materials, the highly enriched uranium and plutonium. These are very specialized materials. Generally, because they are specialized materials, they are under government control.

We mentioned earlier in the discussion that certainly in Russia, Russia pops up to the top of the list because there is hundreds of tons of these materials at various sites, and it is a good thing that over the past 10 years we could work with the Russians to help increase the security, because they are concerned about these issues as well, but the first and last answer to that question always comes around to controlling materials.

Once the materials get out, the nuclear weapons-capable materials, the ability to fashion, construct, even the intention to do so in some strange way, you might say, somebody could be lucky if they have the materials. If their intention is to make it go off, they might be able to do it. That is the concern. So it is controlling the materials, keeping them out of the wrong hands.

The CHAIRMAN. Now, when we talk about materials, I am not going to go into it in open session, but yesterday we actually, though one of your colleagues, know that you folks at the laboratories have been ahead of the game here in that you have been concerned about this possibility for sometime, and that you have actually constructed devices to see how difficult or how hard it would be to determine, to be able to make an informed judgment of how difficult it would be for an informed or uninformed terrorist to build a device, and that would make this nuclear reaction take place, and there are various concerns.

One is the wholesale purchase of a device, and we went through yesterday in closed session the kinds of devices that would theoretically be on the top of the wish list for a terrorist out there trying to purchase such a device, and they genuinely relate to how compact, and the size.

You cannot buy an SS–18 and pack it in your bag and take it over to the United States, or even know how to fire it. An SS–18 is one of the big Soviet missiles with considerable throw weight, multiple warheads independently targeted, et cetera. But there are devices, nuclear devices that weaponize, nuclear devices that are smaller.

The second thing we were told is that there is the concern about being able to construct a device that could cause this nuclear reaction, and therefore the devastation that would follow, and the somewhat good news that I took away from that was that such a device within the realm of possibility ends up being a fairly heavy device. It is not something you can pack in a suitcase. It is not something you can disperse out of the back of a moving vehicle. It is not something that you can carry onto a plane, et cetera.

But nonetheless, there is literature out there that is available to anyone with—and I told you yesterday I had a friend who used to say he was not the brightest candle on the table. He passed away, but he had a lot of common sense. He said, Joe, you have to know how to know. There are folks out there who know how to know, and how to get an open source material, if not literal diagrams, cookbooks for how to actually—and it is difficult, but cookbooks on how to build the device that would cause the nuclear reaction to take place with relatively small amounts. The larger the amounts get, the more complicated this all gets.

Now, what I am leading to is this. I would like you to, if you can, speak to how difficult it is not to get the material, that is, the en-

riched uranium, or the plutonium, the weapons-grade material that causes this nuclear chain reaction, but how difficult is it to get the material that would be required to construct, without describing it, construct the thing that would make it go boom, the apparatus in which this material is placed to cause the chain reaction, and I am trying to be articulate without being specific, and I am probably doing neither.

Dr. COBB. In terms of the discussion here, I would say there is a lot of information. Some of it is incorrect, some of it is just speculation, but there is a lot of information that is out that is available that might lead a terrorist group to think they could do something whether they could or not, and the key to stopping them, again I would go back to say is, the materials that are most difficult for them to get would be, at least from their perception I believe would be, the hardest thing for them to do would be to get the nuclear materials themselves, and so that is always still back to the focus that I said earlier.

The other thing I might mention, you were talking about a spectrum of potential threats, and I am glad you raised that again because if we have to face these kinds of threats then we need to be prepared for a whole spectrum of possibilities, and I mentioned the nuclear support team earlier. Our folks, some of the thinking we are doing is not because we know that these are the specific threats we are going to face tomorrow. It is just that the possibility may occur, so we have got to be prepared, so a lot of this is about just thinking and preparing in advance.

The CHAIRMAN. Well, I want to make that clear as well. I have received, and I will continue to urge all of my colleagues in the Senate to receive, a detailed briefing from the intelligence community as to what we know has occurred or has not occurred, and what we know or believe is being sought and what is not being sought, but it is no longer—I remember when I was first on the Intelligence Committee there was clear evidence that two individuals in other parts of the world had attempted to negotiate purchasing nuclear weapons. It was then a very classified idea.

Since September 11 it has been discussed openly that there is a knowledge that there is a serious desired to purchase wholesale—the easiest way to do this is buy the finished product, not have to find the raw material and then construct from that raw material a device that would make it functional, causing the damage.

Now, the other question I have for you is, just again without getting into classified information, it is clear—those of us who have worked in this area from the layman but policymaker side of the equation know that there are a number of nuclear scientists who are unemployed in the former Soviet Union. There are a number of people who, given the material, given the fissile material, it would not be beyond their capability to construct a very, as the phrase used by Dr. Agnew, a very crude device, a crude nuclear device.

What kind of background does one have to have, and this may be beyond your scope here, but what kind of background, if any of you could speak to this, would one have to have in order to, given access to the material, be able to construct a device that could do significant damage, a nuclear device.

Dr. COBB. Clearly, this is the so-called brain drain problem, and what you are focusing on is the numbers of people who have direct knowledge of nuclear weapons and their construction and their design in the former Soviet Union.

Now, through these cooperative programs with the Russian Federation, we meet some of our colleagues, and I can just say that the people that we talk to are patriots in their own country. We do not see that this brain drain is an epidemic of people leaving to go serve some other country.

Having said that, it is a concern. Clearly, one person with this kind of information and knowledge can change the speculation from a maybe and a wish to something that is more scientifically or engineeringly certain, so it is a concern.

The CHAIRMAN. To summarize my questions to you, and I will ask two more questions and yield to my colleague from Florida, and ask him to chair this because I will have to go to meet the President at 11.

There are really sort of three elements, and this is Joe Biden speaking now. I am not trying to paraphrase you, but just so I understand it and can communicate this accurately to my mother—I have a very bright mother, but she always says to me when I try to explain what I think is a relatively complicated concept, she will look at me and say, Joey, speak English, so I want to make sure that I am able to, quote, speak English, as my mother would say, because I think it is important.

My colleagues and I understand what it is we are facing in order to work with scientists and serious people like you to do all we can to diminish the prospect of any of this occurring. The first is, you need, for a nuclear device, not radiological, you need the raw material, which is enriched uranium, plutonium, there are other possibilities but those are primarily the ones, so-called fissile materials, and that is very difficult to get a hold of, although our concern relates primarily—is it correct, Dr. Meserve, we are fairly confident here in the United States that access to that material—nothing is impossible, I guess. Fort Knox could be held up, too, but it is like Fort Knox. We are talking about a great degree of difficulty, and requiring incredible sabotage or espionage for there to be a release of that material in a way that would go undetected, is that correct?

Dr. MESERVE. That is correct.

The CHAIRMAN. So therefore we look at sources, and there are, the estimates I have—and I do not want to guess at it again, because my memory may not be correct, but there are more than several tons of this material in the Soviet Union, is that correct?

Dr. MESERVE. That is correct. The precise number may be classified, but there are more than hundreds of tons.

The CHAIRMAN. And that is enough to make, if we were dedicated to do it and had it available, thousands of nuclear weapons, correct?

Dr. MESERVE. That is correct.

The CHAIRMAN. Now, we do know that the Russians very badly want to protect that material, but in light of their economic and political circumstances, they are not nearly as equipped to do that as we are in the United States, and they have been working with us

on threat reduction possibilities. This all goes to priorities for us, and what we fund and how we fund it.

So first thing is, protect the source. The most open source, the most likely source, the most vulnerable source, although not porous, is the former Soviet Union, Russia in particular. Is that a fair statement?

Dr. MESERVE. That is correct.

The CHAIRMAN. Would you think that, Dr. Cobb, as well?

Dr. COBB. I would agree.

The CHAIRMAN. Now then, the second feat that has to be overcome beyond getting the material is having the engineering capability, building the box, building the thing, building the device that causes the nuclear reaction to take place, even if you have the material, correct?

Dr. COBB. Plausibly, yes.

The CHAIRMAN. That relates to engineering know-how, some of which is available in the open literature. Some is correct, some is incorrect, some is accurate, some is inaccurate, and our concern relates to the degree of sophistication and knowledge and background, nuclear and engineering background of the individual who is tasked to do that, so Joe Biden would have great difficulty doing that.

As a history and political science major, and a lawyer I would have great difficulty doing that, but someone with real scientific background and knowledge, and particularly if they had worked in the nuclear arena, might not have as much difficulty, correct?

Dr. COBB. That is fair.

The CHAIRMAN. And the material that would be needed to construct such a device, those materials are available on the open market because they are used for other things as well, correct, most of them?

Dr. COBB. To a certain extent.

The CHAIRMAN. And then the third thing to be concerned, so we have to look at either if there are materials that could be used in such a device, we have to deal with controlling those materials to the extent we can if they are not enriched uranium or plutonium, that is the canister, the thing that causes this reaction to take place, and there is more vulnerability there, because many of those elements are used for legitimate purposes.

And the last piece, then, is that the degree to which our intelligence services are able to detect and to interface with other intelligence communities to try to get ahead of the curve here to determine who may be engaged in such activity, and we are working on that to determine whether we beef up our intelligence capacity and our intelligence capability, but there is one piece that I am not fully—I am not fully cognizant of all those pieces, but I am not as certain about, and that is the ability to detect the material, the fissile material that produces the release of nuclear energy, and that is the plutonium or enriched uranium.

Now, if I try to smuggle across a border or into a building a radiological material, a material that is not adequately shielded, we have devices now, do we not, that are in the conventional market that could detect me walking into a building with radiological material in a briefcase, a suitcase, unless it was fully shielded, and

then the more material I have, the more shielding is required, the heavier it is, so there are other ways to look for this material, other than just merely detecting, is that correct, Dr. Meserve?

Dr. MESERVE. That is correct. There is some intricacy here having to do with the type of material, but basically, for many of the materials of concern here, not highly enriched uranium or plutonium, there are detection devices one could have at ports of entry, or going into buildings, or at airports, or what-have-you, to be able to detect them.

The CHAIRMAN. We discussed yesterday in one nonclassified portion of this, if someone were to smuggle in radiological material in a canister, a so-called dirty bomb in a canister—excuse me, a cargo container that theoretically we are able to detect one of two things, either based on the shipment we can detect mass that is designed to shield the radiological material, which would give us a heads-up to take a look at it, or actually detect, have a little geiger counter go off and say, there is radiological material in this big old cargo container, and theoretically that is possible to attach to the crane that picks this device up off a ship and puts it on the back of a tractor trailer, or have a device where you go through just like a metal detector, where the canister or vehicle goes through a metal detector, in effect, and gives you some reading as either the density of the material that is there, and/or the radiological reading, is that correct?

Dr. MESERVE. That is correct.

The CHAIRMAN. Now, I know it is much more complicated and more detailed than this, but I am trying to get at the second issue that Dr. Cobb raised yesterday that I think is very important that we focus on, at least that we focus on, and that is that I think the average person would think it would be easier to detect fissile material, plutonium, uranium being transported than it would be to detect a radiological material because of the consequences.

People think the greater the consequence, the danger, I think instinctively they think, well, the easier it would be able to detect it. In fact, that is not true, is it? In fact, it is very difficult for us to be able to detect, whether or not in a suitcase, in an aircraft, on a train, on a plane, in a cargo ship there is enriched uranium or plutonium, is that correct?

Dr. COBB. Well, let me comment. I think we have been working for years—I think Dr. Koonin pointed out that radiation sensors, devices to do detection, the physical principles are pretty well understood, and we have worked on these for a long time, and we focused on actually the weapons-usable materials, uranium and plutonium, so I guess I would only quibble with the comment that it may be difficult, but there are approaches that have been developed over the years to do the detection.

And without going into a lot of details about different kinds of radiological sources and the radiation they emit, in some sense you do get almost for free, because you have been working the uranium problems and plutonium problems, some capability to detect these other types of materials.

The CHAIRMAN. The reason I mentioned that, and I will cease with this, is that again, in terms of priority for policymakers, and we are talking about taking limited dollars to deal with threats

that are posed, if we could, if we could develop on a larger scale, and with more precision, detection devices that would expose the presence of nuclear-capable material, that is enriched uranium, plutonium, et cetera, that that is something we physically would be able to improve on and do, but it comes down to a question of, we have not done it extensively yet. I imagine it is fairly costly.

For example, when we talk about borders, one of the questions that my friend from Florida and I talk about privately is, he represents the State of Florida. There are millions upon millions, over the period of time, of cargo containers on ships that come into his state, and so should we be looking at ports of embarkation where this material, where things leave—whether it is Le Havre, or whether it is London, whether it is Vladivostok, wherever, a cargo container is placed on a ship. Should we begin—and I am not asking you the question unless you want to answer it, should we begin to negotiate trade agreements with other countries saying, we want to be able to inspect on the dock, at the port of embarkation, materials that are being sent to us?

I mean, there is a lot we have to think about. That is the only point I am trying to get to, but it is within the realm of scientific possibility and capability to be able to enhance the prospect of detecting the transfer of this weapons-grade material, is it not?

Dr. COBB. I think it is consistent with the thought that you need as much layers in your protection as you can afford and you can put in place.

Dr. MESERVE. Senator, if I might add a thought, however, I think the consequences, if this material were to come into the United States and were to be exploited by a terrorist, are so severe that you would need to look at the whole range of options to be able to deal with it.

Probably the single most effective thing that we could do is to try to control these materials at the source, because of the difficulty in detection. We have long borders and there is the possibility that something could get through. Control at the source is the one place where we really could assure ourselves of great progress. I think that ought to remain the place where our attention is primarily focused, not to discourage these other things as well as backup, part of a defense in depth.

The CHAIRMAN. Well, I have never before, and I am not deliberately now standing up a President of the United States—it is almost 11—but there are other colleagues there, and I am sure he will not miss me, and I hope they will allow me to enter this meeting late, but let me conclude with one comment, or one question and one comment.

Dr. Koonin, your presentation has been extremely helpful, and I truly appreciate the fact that you have emphasized, as all of you have, that the life-threatening consequences of the easiest—if I may, the easiest radiological terrorist activities that they could undertake are de minimis, but part of this is, I am of the view that educating the public as to the nature of the threat and the consequences of the action enhance our ability significantly to deal with it.

I said to you gentlemen yesterday, and this is pure conjecture on my part, and I will probably get 10,000 letters disagreeing with me,

but God forbid we have another anthrax letter, of weapons-grade anthrax, or something approaching that. I have a feeling the American public will adjust to it and move through it with a greater degree of confidence than we did before, because we know more, and we know that at the end of the day, as devastating as it was, there were a half dozen or so people who lost their lives, incredibly bad.

That was terrible, but it is not what I think some people envisioned, that I would go home during this period and people would say to me, am I going to open up my mail and will my whole family die, and will the neighborhood be taken down, et cetera, and so I think there is a sense of proportion that is being established here.

It is an awful reality we have to deal with. It is a shame we have to be educated about this at all, so I appreciate, doctor, you putting this in a context, but my question is, it is clear that handling radioactive material, you can learn how to do it, but it is still a difficult process, the larger the amounts and the greater the danger one is exposed to.

What about the handling of plutonium and enriched uranium? How difficult is it to physically handle, assuming you got access to it?

Dr. KOONIN. If you want to do it safely, it is very difficult, and we have facilities at the national laboratories that are very secure, expensive, safe, in order to do just that. However, if you are willing to die for what you are doing, then it would be quite easy to deal with large amounts of highly enriched uranium [HEU], or plutonium.

Radiological materials could induce death within minutes to hours, but again you do not need a very strong source in order to cause a lot of trouble.

The CHAIRMAN. The last thing I would like to do is thank the panel and ask your indulgence that if we desire to have you back at another time, whether you would be willing to consider giving us the benefit of your wisdom, and possibly in a slightly different context for an additional hearing. Would you be willing to do that?

Dr. MESERVE. Of course.

The CHAIRMAN. Thank you.

Senator NELSON. Mr. Chairman, I have to be presiding at 11.

The CHAIRMAN. I am sorry I did not give you a chance to ask questions. I thought you were able to stay.

Senator NELSON. I understand you are going to recess this until 2:30.

The CHAIRMAN. Yes, I am going to recess the hearing until this afternoon. I started my day at 5 a.m. as my father underwent a minor operation this morning at 6 a.m., so we are going to recess until 2:30. I realize Drs. Meserve and Cobb are unable to return this afternoon. Are you able, Dr. Koonin, to be available at 2:30?

Dr. KOONIN. I am, indeed.

The CHAIRMAN. We will resume at 2:30 with Dr. Kelly, Dr. Koonin, and Dr. Vantine, and I appreciate your indulgence, gentlemen. Thanks for the accommodation. I appreciate it a whole lot. We are in recess until 2:30.

[Whereupon, at 10:55 a.m., the committee adjourned, to reconvene at 2:30 p.m., the same day.]

AFTERNOON SESSION

The committee met, pursuant to notice, at 3 p.m. in room SD–419, Dirksen Senate Office Building, Hon. Joseph R. Biden, Jr. (chairman of the committee), presiding.

The CHAIRMAN. The hearing will reconvene. It seems all I'm doing today is apologizing to witnesses, and I do apologize. You're all incredibly busy and important men, and what you have to say is of great consequence to us, and I do apologize.

We had—as the Senator from Florida probably told you, we had President Mubarak here, and we had a little followup with the President a moment ago. There's a judge the President is interested in. At any rate—it is hard to say, "I've got witnesses waiting"—but, unfortunately I'm not able to help them. But, having said that, why don't we begin?

And let me invite Dr. Kelly, if you would be willing to make your statement. And, by the way, we owe something beyond the glass of water we're giving Dr. Koonin. He was here this morning, and he is here this afternoon, and he has been kept waiting in the meantime.

Dr. Kelly, I introduced you, in your absence this morning, by pointing out that you are here to discuss a recent FAS study on the effects of dirty radiological bombs. And I understand you're going to show us some specifics of how such a device may affect American cities. And you've spent over 7 years as Director of Technology in the White House Office of Science and Technology, and you've worked at the Congressional Office of Technology Assessment, where you were an Assistant Director of what is now known as the National Renewable Energy Laboratory.

So, doctor, why don't you begin, and then we will go to Dr. Vantine, who gave us a great presentation yesterday, as well, and I will introduce him at that time. Please proceed.

STATEMENT OF DR. HENRY C. KELLY, PRESIDENT, FEDERATION OF AMERICAN SCIENTISTS, WASHINGTON, DC

Dr. KELLY. Thank you very much, and I certainly appreciate the committee's attempt to try to understand this very difficult subject and bring what we think is a very critical problem to the public's attention. I would like to begin by thanking two of my colleagues here, two physicists, Mike Levi and Robert Nelson, who have worked with FAS to do the analysis.

The CHAIRMAN. Thank you for being here, gentlemen.

Dr. KELLY. So what I'm going to do here is concentrate on the impact of radiological attacks using comparatively small amounts of radioactive material. And I guess I have three main points I want to make here. First is that the threat of an attack using these radiological materials——

The CHAIRMAN. For years and years in the Senate, I served either as chairman or ranking member with Senator Thurmond, and he had the best explanation. He said, "You've got to speak into the machine." With all our great technology, you will notice that this hearing room has a terribly inadequate PA system, and poor Bertie has to work with it all the time. But you have to speak right into the machine, as Senator Thurmond would say.

Dr. KELLY. I remember reading a candidate in New York City spoke to 20,000 people in 1960, and I always wondered—without any amplification. So those were the days when lung-power counted.

The CHAIRMAN. He was obviously desperate.

Dr. KELLY. Well, what I want to do is make three points. The first is that the danger presented by radiological attack is very real and credible. Anything of significant size is not going to be trivial to undertake, but it's certainly not beyond the capacity of a sophisticated organization.

A second point is that any attack that makes any reasonable sense is not going to kill a large number of people. If that is your aim, this is not the appropriate tool, nor will it even injure a large number of people, so that it will be a comparatively small number of people that will be getting radiation sickness from this kind of attack. The main danger is contaminating significant areas with material that would require very expensive cleanup and could be extremely disruptive and could, without proper emergency response, create considerable panic. And, of course, you could deny economic use of large areas.

Now, one of the things that needs to be put on the table to put this in perspective, what you did this morning, is that this needs to be clearly distinguished from a nuclear weapon. This doesn't create an explosion. A nuclear weapon would be killing tens, hundreds of thousands of people, and it is an order of magnitude different. And so that this issue needs to be kept in perspective.

And I guess my third point is that—the good news in all of this is that, while this is a new class of threats that we need to take seriously, there are a number of very constructive things that we can do to vastly reduce the threat. This is a problem which, compared to a lot of the other things we're facing, is fairly solvable.

Now, let me just quickly go through why we think this is a problem. And the problem is basically that we are using radioactive materials in many parts of our economy—and this, again, was discussed this morning—but they're extremely valuable in application—from making food safe, to medical facilities, to finding oil, smoke detectors, many other things we count on for our economy. So they are distributed in quite large numbers around the United States and around the world.

Now, in the past, our main concern about nuclear materials has been, in the first instance: Is there enough material to make a nuclear weapon? And we have, certainly in the United States and in most parts of the world, made very sure that we have control of any amount of radioactive material that could be used to make a weapon. And——

The CHAIRMAN. Do you have a high degree of confidence in that statement, doctor?

Dr. KELLY. I certainly have it in the United States. You discussed the problem of controlling it in the former Soviet Union, and I think it is a real problem, but in the United States, our Department of Energy and the national labs have done, I think, a spectacular job of maintaining control over this material. So that means that there are smaller amounts of material and radioactive samples that are used—that cannot be used to make a nuclear weapon.

And, in the past, of course, our main concern about this stuff has been making sure that the workers who are handling it were well protected, that it wasn't lost or stolen or led to public health dangers of one kind or another. There was concern about theft, but mainly because it had the economic value. Somebody would steal it for—often by accident, using it for scrap metal, but there was never any thought of malicious intent, other than an honorable thief looking for a quick buck.

The notion that someone would steal this material for malicious intent and actually try to turn it into a radiological weapon has created a whole new class of threats, and that is what has put this issue on the table on what to do about that.

What we have done is some very simple calculations just to show the danger presented by many of the classes of materials that are out there. What we have done is use a computer program that is used to help emergency-response teams understand what areas might be contaminated.

So I'm just going to take two examples. One is a very small piece of cesium, roughly the size of the piece of cesium that was found in North Carolina a couple of weeks ago that had accidentally found its way into a steel mill. And let's see if I can get the technology to work for me. We're assuming you simply blow this material up at the foot of Capitol Hill. And what happens is, if——

The CHAIRMAN. How much material are we talking about now in this slide? [1]

Dr. KELLY. Well, it's 2 curies, the size of the material that was found in North Carolina. And we've assumed that it's broken up into tiny particles and settles around Capitol Hill. And I have—we've calculated three circles here. The inner circle, the smaller one, you have one chance in a hundred of getting cancer in that area. Now, that's roughly the risk that is taken already by a nuclear worker, radiation workers. So over their lifetime, they get roughly the same exposure. So at least for that class of people, we would, you know, have been willing to take that risk. The middle ring is one chance in a thousand of getting cancer. And the outer ring is one chance in ten thousand.

Now, this assumes that you are—to get this cancer risk, you have to be there for—you have to live there for 40 years to get that level of risk.

The CHAIRMAN. So it's not merely that if you're intially exposed to this—let's say you're walking down the mall—that looks like the mall or the ellipse.

Dr. KELLY. Yes, I think——

The CHAIRMAN. What you have there?

Dr. KELLY. Yes.

The CHAIRMAN. You're walking down the mall, and this thing would go off. If you're in the first small circle, and you are immediately evacuated from that area, is your risk still one in a hundred?

Dr. KELLY. Oh, no. You would have to—your risk would be—the risk of—if you just walked out of here, your risk would be almost

[1] This reference is to slides of maps being displayed by Dr. Kelly during his testimony. The maps are part of his prepared statement that begins on page 37.

non-existent. The only people likely to be hurt in this are likely to be hurt either by the weapon itself, the explosion——

The CHAIRMAN. The actual explosion, right.

Dr. KELLY [continuing]. Or if there's panic——

The CHAIRMAN. Yes.

Dr. KELLY [continuing]. Which is something you want to be worried about. So the reason for showing these contours, however, is that the areas that are exposed——

The CHAIRMAN. Right.

Dr. KELLY [continuing]. Have to be cleaned up.

The CHAIRMAN. Right.

Dr. KELLY. And one of the problems in the outer ring is the EPA threshold that was actually discussed earlier. It's the Superfund threshold, one in ten thousand. Now, one thing you have to understand about that level is that it's an extremely low level or risk. It's about—we're saying you have one chance in twenty of dying of cancer, in any event, and this makes it—increases it by this one in ten thousand. So this is—you're also exposed to a background level of radiation all the time. No amount is good for you, but we get it from cosmic rays, we get it from radon from the soil. You know every—you're rolling the dice every time one of these radioactive rays goes through your body. And so the more times you roll the dice, the higher your probability is. But this increases the risk only about—by a factor of one-twentieth above background.

Nonetheless, it is the level that EPA sets as the area which they recommend decontamination. And one of the dilemmas you face is that this stuff is pretty hard to decontaminate. In the case of cesium, it binds to asphalt and concrete. It can get into the air-conditioning system. And if anything like—if it had gotten into the Hart Office Building, you couldn't, for example, just pump chlorine into it and kill this stuff. I mean, it is very hard to get out and, in many cases, you probably would have to demolish the buildings or reconsider whether this threshold really makes sense, because this is a——

The CHAIRMAN. Reconsider the one in ten thousand standard?

Dr. KELLY. Yes. I mean, you'd be faced with that decision about——

The CHAIRMAN. Yes.

Dr. KELLY. Now, the second example I have is taking a comparatively large source of cobalt of the sort that is used in devices around the country, and detonating it at the tip of Manhattan. Now, here you see the rings are—these are the same three rings here, so you're basically——

The CHAIRMAN. Rings are elliptically shaped because that represents wind—the direction of the wind, or whatever, just arbitrarily——

Dr. KELLY. Yes; we just picked—low wind, but the wind just happened to be blowing to the northeast. Now, one of the things that I should emphasize is that all of these calculations—if you read the manual for the first-responder calculation, they say that the—there are huge errors associated with these calculations, because it depends on the tails of the wind and where the buildings are located and all sorts of other assumptions. So this is not an absolute forecast——

The CHAIRMAN. Gotcha.

Dr. KELLY [continuing]. But it's a reasonable scenario of what could happen. And again, you can see that you have, in this case, quite significant areas that are affected, including some agricultural areas you'd have to worry about. And the other point here, though, is that anybody who tries to actually handle this kind of material would have to be quite a sophisticated person, because just holding this—if you held or were close to one of these for even a few minutes, you'd get a fatal dose of radiation and be incapacitated within an hour. So this is not a simple task to do.

I want to just give you another point of comparison. We tried to use the Russian standard at Chernobyl as a point of comparison, and given the contamination levels that would have come from this cobalt explosion that I was just describing, the inner ring is the area that the Russians closed permanently as a result of the Chernobyl accident. So this is just to give you an indicator of the——

The CHAIRMAN. Is that the tip of Manhattan island we're looking at?

Dr. KELLY. Yes, it's detonated right down at the tip.

The CHAIRMAN. OK.

Dr. KELLY. And, of course, this is a slightly different wind pattern that we've got——

The CHAIRMAN. Yes.

Dr. KELLY [continuing]. And it just goes up——

The CHAIRMAN. Yes.

Dr. KELLY. It's just to give you a sense of scale. But the point of this is—and again, you—the level of risks at the far end of this are high, but if you walk out of this thing, even in this case, very few people are going to be killed through direct effects. There are always freak events where you'd have a hot spot and some could get a high dosage, but this is not going to be—if people are safely evacuated, you're not going to be killing significant numbers of people.

So the question at the end, then, is if this is quite a serious threat and a credible threat, as you said in your opening remarks, one of the things we all need to face up to here after September 11, is to take a very hardheaded look at the real risks faced by the United States and find out whether our resources are being aligned with where the real risks are and where we can do some good. This is clearly an area where we can do some good and where at least we believe the risks are quite high.

And we have three classes of recommendations, which largely follow the statements that have already been made. There seems to be an amazing consensus here on how to proceed. First of all, you want to reduce opportunity for the terrorists or any malefactors to get hold of this material to begin with. Second, you'd like to have very early warning to detect any illicit movement of this. And, third, you want to minimize casualties and panic that would result if such an event actually occurred.

And let me give a few specific things that I think would qualify in each one of those areas. I think we really do congratulate Dr. Meserve and the activities of the NRC to face up to this new class of challenge for his materials. But we plainly need to take a fresh

look at the procedures under which people obtain high levels of radioactive materials, the safety and security procedures, and tracking these materials throughout their lifetime.

Another thing we need to do is to beef up our intelligence, both through domestic police work and through close cooperation internationally, in making sure that we keep close track of both the legal and illegal movements of this material. And I should hasten to say that virtually every problem we're facing here in the United States is being faced in Europe and most parts of the world, so it really makes sense to approach almost all of these problems through international collaborations and perhaps even cost sharing where it's appropriate.

One place where this might be particularly appropriate is looking for technical alternatives to radiation. Right now we use radioactive materials to sterilize food and to do logging and other things, because it's the cheapest way to do it. Now, what will happen if you start applying rigorous security to some of those facilities, the price of doing it that way might go up. And one thing that is likely to happen is that it will stimulate technology that is not high risk that could do the same job, maybe at a slightly higher price. And we think that it's probably appropriate for the laboratories and other organizations to actually engage actively in research and search for alternatives, particularly for these higher-level sources of radioactive material.

One specific problem that people have had is that there's a lot of—is getting rid of radioactive material when it's no longer being used. And there are—it's a terrible problem, but if you've got a sample in a laboratory or in a company that's gone bankrupt or just is going to some other line of work, what do you do with this stuff? In most cases, the Department of Energy is the only organization allowed to come and pick the stuff up and move it to a safe site.

And there's a program in DOE called the Offsite Source Recovery Project, which we think has been chronically underfunded. These are guys who just go out in trucks, locate these sources, pick them up and take them to a safe place. And it seems, to us, silly to have people who don't want this material forced to keep it because this program is underfunded.

The second thing I mentioned was early detection, and there are a lot of—there's a need to put radiation detectors in many different pinch points, ports, bridges, tunnels, and other areas, and also a need to develop improved detectors. And there are a lot of things that can be done and are being done at the labs and other places to increase our ability to detect movement of all kinds. A lot of them are sophisticated systems where the more different detectors you network together, the better able you are to get patterns and eliminate false alarms. And we would strongly support increasing research and testing as well as deploying things we already know how to do.

And then, finally, in the event that you actually do have an incident, there are—the first thing you need to do it to make sure that people who respond to the emergency are able to control panic and are able to treat any people who have real symptoms. Emergency response training is key. One very important thing is that this—

an attack of this sort would generate a lot of panic. There was a case in Brazil where a large amount of cesium was released inadvertently in a neighborhood, and huge numbers of people in the town showed up at the emergency rooms. Some of them had radiation-sickness symptoms. They were nauseous and had physical symptoms. But only fewer than 10 percent of them actually had anything approaching dangerous levels of exposure. It was purely psychosomatic stress. And if the emergency responders aren't prepared to deal with this kind of problem and do instant triage, you could have chaos at the health facility.

We have some concern that, while a lot of money is being directed into first-responder training, that there is a real need to take a tight, controlled approach to this rather than simply spread it out to all the states and hope for the best.

The CHAIRMAN. Tight control of the training?

Dr. KELLY. Yes. Things like quality control over the materials. There's a lot of people who are still training with obsolete information. And, as you know, we are learning, rapidly, new things about the nature of these threats and how to respond and trying to update everybody's field manual in the realtime is not a very practical thing to do. Fortunately, the Internet and other tools like this should make it easier to do that. You'd also like to have some kind of peer review or quality control for the materials which are being sent out to these people. And again, advanced information-based training systems seem to cry out for this.

The Defense Department and the labs have started to work in this area, but we sense that there is a real need to get some infrastructure here to make sure that good material is easy to find and distributed quickly out to the very large number of people who need it. There are 2.7 million nurses and over a million police and fire alone, let alone emergency responders.

So in the end, we're concluding that this is a very serious security problem from radiological attack, from sources that are spread throughout the economy. One of the things I haven't talked about is nuclear reactor fuel rods. Of course, these have many times more nuclear radioactive material in these rods than anything that I've been talking about. But also trying to acquire and move and manipulate these is also many times more difficult. So I haven't formally considered that here. But the good news, of course, is that with some prompt and very practical things, we can hugely reduce the risk of these kinds of attacks.

I have to conclude by saying that in the long run, there's no way we can reduce this risk to zero. And one of the things we plainly need to do is to try to find a way to build a world where the kind of people who would even contemplate this kind of attack aren't being bred and trained. But I really do thank the committee for engaging this. I think it's very timely, and I look forward to being able to work with you.

[The prepared statement of Dr. Kelly follows:]

PREPARED STATEMENT OF DR. HENRY C. KELLY, PRESIDENT, FEDERATION OF AMERICAN SCIENTISTS

INTRODUCTION

Surely there is no more unsettling task than considering how to defend our nation against individuals and groups seeking to advance their aims by killing and injuring innocent people. But recent events make it necessary to take almost-inconceivably evil acts seriously. We are all grateful for the Committee's uncompromising review of these threats and its search for responses needed to protect our nation. Thank you for the opportunity to support these efforts.

My remarks today will review the dangers presented by radiological attacks, situations where nuclear materials that could be released, without using a nuclear explosive device, for the malicious propose of killing or injuring American citizens and destroying property. Our analysis of this threat has reached three principle conclusions:

1. Radiological attacks constitute a credible threat. Radioactive materials that could be used for such attacks are stored in thousands of facilities around the U.S., many of which may not be adequately protected against theft by determined terrorists. Some of this material could be easily dispersed in urban areas by using conventional explosives or by other methods.
2. While radiological attacks would result in some deaths, they would not result in the hundreds of thousands of fatalities that could be caused by a crude nuclear weapon. Attacks could contaminate large urban areas with radiation levels that exceed EPA health and toxic material guidelines.
3. Materials that could easily be lost or stolen from U.S. research institutions and commercial sites could contaminate tens of city blocks at a level that would require prompt evacuation and create terror in large communities even if radiation casualties were low. Areas as large as tens of square miles could be contaminated at levels that exceed recommended civilian exposure limits. Since there are often no effective ways to decontaminate buildings that have been exposed at these levels, demolition may be the only practical solution. If such an event were to take place in a city like New York, it would result in losses of potentially trillions of dollars.

The analysis I will summarize here was conductd by Michael Levi, Director of the Strategic Security Program at the Federation of American Scientists (FAS), and by Dr. Robert Nelson of Princeton University and FAS.

BACKGROUND

Materials are radioactive if their atomic nuclei (or centers) spontaneously disintegrate (or decay) with high-energy fragments of this disintegration flying off into the environment. Several kinds of particles can so be emitted, and are collectively referred to as radiation. Some materials decay quickly, making them sources of intense radiation, but their rapid decay rate means that they do not stay radioactive for long periods of time. Other materials serve as a weaker source of radiation because they decay slowly. Slow rates of decay mean, however, that a source may remain dangerous for very long periods. Half of the atoms in a sample of cobalt-60 will, for example, disintegrate over a five year period, but it takes 430 years for half of the atoms in a sample of americium-241 to decay.

The radiation produced by radioactive materials provides a low-cost way to disinfect food, sterilize medical equipment, treat certain kinds of cancer, find oil, build sensitive smoke detectors, and provide other critical services in our economy. Radioactive materials are also widely used in university, corporate, and government research laboratories. As a result, significant amounts of radioactive materials are stored in laboratories, food irradiation plants, oil drilling facilities, medical centers, and many other sites.

A. Commercial Uses

Radioactive sources that emit intense gamma-rays, such as cobalt-60 and cesium-137, are useful in killing bacteria and cancer cells. Gamma-rays, like X-rays, can penetrate clothing, skin, and other materials, but they are more energetic and destructive. When these rays reach targeted cells, they cause lethal chemical changes inside the cell.

Plutonium and americium also serve commercial and research purposes. When plutonium or americium decay, they throw off a very large particle called an alpha particle. Hence, they are referred to as alpha emitters. Plutonium, which is used in nuclear weapons, also has non-military functions. During the 1960s and 1970s the federal government encouraged the use of plutonium in university facilities studying

nuclear engineering and nuclear physics. Americium is used in smoke detectors and in devices that find oil sources. These devices are lowered deep into oil wells and are used to detect fossil fuel deposits by measuring hydrogen content as they descend.

B. Present Security

With the exception of nuclear power reactors, commercial facilities do not have the types or volumes of materials usable for making nuclear weapons. Security concerns have focused on preventing thefts or accidents that could expose employees and the general public to harmful levels of radiation. A thief might, for example, take the material for its commercial value as a radioactive source, or it may be discarded as scrap by accident or as a result of neglect. This system works reasonably well when the owners have a vested interest in protecting commercially valuable material. However, once the materials are no longer needed and costs of appropriate disposal are high, security measures become lax, and the likelihood of abandonment or theft increases.

Concern about the intentional release of radioactive materials changes the situation in fundamental ways. We must wrestle with the possibility that sophisticated terrorist groups may be interested in obtaining the material and with the enormous danger to society that such thefts might present.

Significant quantities of radioactive material have been lost or stolen from U.S. facilities during the past few years and thefts of foreign sources have led to fatalities. In the U.S., sources have been found abandoned in scrap yards, vehicles, and residential buildings. In September, 1987, scavengers broke into an abandoned cancer clinic in Goiania, Brazil and stole a medical device containing large amounts of radioactive cesium. An estimated 250 people were exposed to the source, eight developed radiation sickness, and four died.

In almost all cases, the loss of radioactive materials has resulted from an accident or from a thief interested only in economic gain. In 1995, however, Chechen rebels placed a shielded container holding the Cesium-137 core of a cancer treatment device in a Moscow park, and then tipped off Russian reporters of its location. The only reported death from terrorist use of a radioactive material occurred when a Russian mafia group hid a radioactive source below the office chair of a businessman, killing him after a few days of exposure.

Enhanced security measures at commercial sites that use dangerous amounts of radioactive material are likely to increase the cost of using radioactive materials and may possibly stimulate development and use of alternative technologies for some applications.

C. Health Risks

Gamma rays pose two types of health risks. Intense sources of gamma rays can cause immediate tissue damage, and lead to acute radiation poisoning. Fatalities can result from very high doses. Long-term exposure to low levels of gamma rays can also be harmful because it can cause genetic mutations leading to cancer. Triggering cancer is largely a matter of chance: the more radiation you're exposed to, the more often the dice are rolled. The risk is never zero since we are all constantly being bombarded by large amounts of gamma radiation produced by cosmic rays, which reach us from distant stars. We are also exposed to trace amounts of radioactivity in the soil, in building materials, and other parts of our environment. Any increase in exposure increases the risk of cancer.

Alpha particles emitted by plutonium, americium and other elements also pose health risks. Although these particles cannot penetrate clothing or skin, they are harmful if emitted by inhaled materials. If plutonium is in the environment in particles small enough to be inhaled, contaminated particles can lodge in the lung for extended periods. Inside the lung, the alpha particles produced by plutonium can damage lung tissue and lead to long-term cancers.

CASE STUDIES

We have chosen three specific cases to illustrate the range of impacts that could be created by malicious use of comparatively small radioactive sources: the amount of cesium that was discovered recently abandoned in North Carolina, the amount of cobalt commonly found in a single rod in a food irradiation facility, and the amount of americium typically found in oil well logging systems. The impact would be much greater if the radiological device in question released the enormous amounts of radioactive material found in a single nuclear reactor fuel rod, but it would be quite difficult and dangerous for anyone to attempt to obtain and ship such a rod without death or detection. The Committee will undoubtedly agree that

the danger presented by modest radiological sources that are comparatively easy to obtain is significant as well.

Impact of the release of radioactive material in a populated area will vary depending on a number of factors, many of which are not predictable. Consequences depend on the amount of material released, the nature of the material, the details of the device that distributes the material, the direction and speed of the wind, other weather conditions, the size of the particles released (which affects their ability to be carried by the wind and to be inhaled), and the location and size of buildings near the release site. Uncertainties inherent in the complex models used in predicting the effects of a radiological weapon mean that it is only possible to make crude estimates of impacts; the estimated damage we show might be too high by a factor often, or underestimated by the same factor. The following examples are then fairly accurate illustrations, rather than precise predictions.

In all three cases we have assumed that the material is released on a calm day (wind speed of one mile per hour). We assume that the material is distributed by an explosion that causes a mist of fine particles to spread downwind in a cloud. The blast itself, of course, may result in direct injuries, but these have not been calculated. People will be exposed to radiation in several ways.

- First, they will be exposed to material in the dust inhaled during the initial passage of the radiation cloud, if they have not been able to escape the area before the dust cloud arrives. We assume that about 20% of the material is in particles small enough to be inhaled. If this material is plutonium or americium (or other alpha emitters), the material will stay in the body and lead to long term exposure.
- Second, anyone living in the affected area will be exposed to material deposited from the dust that settles from the cloud. If the material contains cesium (or other gamma emitters) they will be continuously exposed to radiation from this dust, since the gamma rays penetrate clothing and skin. If the material contains plutonium (or other alpha emitters), dust that is pulled off the ground and into the air by wind, automobile movement, or other actions will continue to be inhaled, adding to exposure.
- In a rural area, people would also be exposed to radiation from contaminated food and water sources.

The EPA has a series of recommendations for addressing radioactive contamination that would likely guide official response to a radiological attack. Immediately after the attack, authorities would evacuate people from areas contaminated to levels exceeding these guidelines. People who received more than twenty-five times the threshold dose for evacuation would have to be taken in for medical supervision.

In the long term, the cancer hazard from the remaining radioactive contamination would have to be addressed. Typically, if decontamination could not reduce the danger of cancer death to about one-in-ten-thousand, the EPA would recommend the contaminated area be eventually abandoned. Decontaminating an urban area presents a variety of challenges. Several materials that might be used in a radiological attack can chemically bind to concrete and asphalt, while other materials would become physically lodged in crevices on the surface of buildings, sidewalks and streets. Options for decontamination would range from sandblasting to demolition, with the latter likely being the only feasible option. Some radiological materials will also become firmly attached to soil in city parks, with the only disposal method being large scale removal of contaminated dirt. In short, there is a high risk that the area contaminated by a radiological attack would have to be deserted.

We now consider the specific attack scenarios. The first two provide examples of attacks using gamma emitters, while the last example uses an alpha emitter. In each case, we have calculated the expected size of the contaminated area, along with other zones of dangerously high contamination. The figures in the Appendix[1] provide a guide to understanding the impact of the attacks.

EXAMPLE 1—CESIUM (GAMMA EMITTER)—FIGURE 1

Two weeks ago, a lost medical gauge containing Cesium was discovered in North Carolina. Imagine that the Cesium in this device was exploded in Washington, DC in a bomb using ten pounds of TNT. The initial passing of the radioactive cloud would be relatively harmless, and no one would have to evacuate immediately. But what area would be contaminated? Residents of an area of about five city blocks, if they remained, would have a one-in-a-thousand chance of getting cancer. A swath about one mile long covering an area of forty city blocks would exceed EPA contami-

[1] See figures 1 through 5 at end of statement.

nation limits, with remaining residents having a one-in-ten thousand chance of getting cancer. If decontamination were not possible, these areas would have to be abandoned for decades. If the device was detonated at the National Gallery of Art, the contaminated area might include the Capitol, Supreme Court, and Library of Congress, as seen in figure one.

EXAMPLE 2—COBALT (GAMMA EMITTER)—FIGURES 2 AND 3

Now imagine if a single piece of radioactive cobalt from a food irradiation plant was dispersed by an explosion at the lower tip of Manhattan. Typically, each of these cobalt "pencils" is about one inch in diameter and one foot long, with hundreds of such pieces often being found in the same facility. Admittedly, acquisition of such material is less likely than in the previous scenario, but we still consider the results, depicted in figure two. Again, no immediate evacuation would be necessary, but in this case, an area of approximately one-thousand square kilometers, extending over three states, would be contaminated. Over an area of about three hundred typical city blocks, there would be a one-in-ten risk of death from cancer for residents living in the contaminated area for forty years. The entire borough of Manhattan would be so contaminated that anyone living there would have a one-in-a-hundred chance of dying from cancer caused by the residual radiation. It would be decades before the city was inhabitable again, and demolition might be necessary.

For comparison, consider the 1986 Chernobyl disaster, in which a Soviet nuclear power plant went through a meltdown. Radiation was spread over a vast area, and the region surrounding the plant was permanently closed. In our current example, the area contaminated to the same level of radiation as that region would cover much of Manhattan, as shown in figure three. Furthermore, near Chernobyl, a larger area has been subject to periodic controls on human use such as restrictions on food, clothing, and time spent outdoors. In the current example, the equivalent area extends fifteen miles.

To summarize the first two examples, materials like cesium, cobalt, iridium, and strontium (gamma emitters) would all produce similar results. No immediate evacuation or medical attention would be necessary, but long-term contamination would render large urban areas useless, resulting in severe economic and personal hardship.

EXAMPLE 3—AMERICIUM (GAMMA EMITTER)—FIGURES 4 AND 5

A device that spread materials like americium and plutonium would present an entirely different set of risks. Consider a typical americium source used in oil well surveying. If this were blown up with one pound of TNT, people in a region roughly ten times the area of the initial bomb blast would require medical supervision and monitoring, as depicted in figure four. An area 30 times the size of the first area (a swath one kilometer long and covering twenty city blocks) would have to be evacuated within half an hour. After the initial passage of the cloud, most of the radioactive materials would settle to the ground. Of these materials, some would be forced back up into the air and inhaled, thus posing a long-term health hazard, as illustrated by figure five. A ten-block area contaminated in this way would have a cancer death probability of one-in-a-thousand. A region two kilometers long and covering sixty city blocks would be contaminated in excess of EPA safety guidelines. If the buildings in this area had to be demolished and rebuilt, the cost would exceed fifty billion dollars.

RECOMMENDATIONS

A number of practical steps can be taken that would greatly reduce the risks presented by radiological weapons. Our recommendations fall into three categories: (1) Reduce opportunities for terrorists to obtain dangerous radioactive materials, (2) Install early warning systems to detect illicit movement of radioactive materials, and (3) Minimize casualties and panic from any attack that does occur. Since the U.S. is not alone in its concern about radiological attack, and since we clearly benefit by limiting access to dangerous materials anywhere in the world, many of the measures recommended should be undertaken as international collaborations.

(1) Reduce access to radioactive materials

Radioactive materials facilitate valuable economic, research and health care technologies. Measures needed to improve the security of facilities holding dangerous amounts of these materials will increase costs. In some cases, it may be worthwhile to pay a higher price for increased security. In other instances, however, the development of alternative technologies may be the more economically viable option. Specific security steps include the following:

- *Fully fund material recovery and storage programs.* Hundreds of plutonium, americium, and other radioactive sources are stored in dangerously large quantities in university laboratories and other facilities. When these materials are actively used and considered a valuable economic asset, they are likely to be well protected. But in all too many cases they are not used frequently, resulting in the risk that attention to their security will diminish over time. At the same time, it is difficult for the custodians of these materials to dispose of them since in many cases only the DOE is authorized to recover and transport them to permanent disposal sites. The DOE Off-Site Source Recovery Project (OSRP), which is responsible for undertaking this task, has successfully secured over three-thousand sources and has moved them to a safe location. Unfortunately, the inadequate funding of this program serves as a serious impediment to further source recovery efforts. Funding for OSRP has been repeatedly cut in the FY2001 and 2002 budgets and the presidential FY2003 budget proposal, significantly delaying the recovery process. In the cases of FY01 and FY02, the 25% and 35% cuts were justified as money being tansferred to higher priorities; the FY03 would cut funding by an additional 26%. This program should be given the needed attention and firm goals should be set for identifying, transporting, and safeguarding all unneeded radioactive materials.
- *Review licensing and security requirements and inspection procedures for all dangerous amounts of radioactive material.* HHS, DOE, NRC and other affected agencies should be provided with sufficient funding to ensure that physical protection measures are adequate and that inspections are conducted on a regular basis. A thorough reevaluation of security regulations should be conducted to ensure that protective measures apply to amounts of radioactive material that pose a homeland security threat, not just those that present a threat of accidental exposure.
- *Fund research aimed at finding alternatives to radioactive materials.* While radioactive sources provide an inexpensive way to serve functions such as food sterilization, smoke detection, and oil well logging, there are sometimes other, though possibly more expensive, ways to perform the same functions. A research program aimed at developing inexpensive substitutes for radioactive materials in these applications should be created and provided with adequate funding.

(2) Early Detection

- *Expanded use of radiation detection systems.* Systems capable of detecting dangerous amounts of radiation are comparatively inexpensive and unobtrusive. Many have already been installed in critical locations around Washington, DC, at border points and throughout the U.S. The Office of Homeland Security should act promptly to identify all areas where such sensors should be installed, ensure that information from these sensors is continuously assessed, and ensure adequate maintenance and testing. High priority should be given to key points in the transportation system, such as airports, harbors, rail stations, tunnels, highways. Routine checks of scrap metal yards and land fill sites would also protect against illegal or accidental disposal of dangerous materials.
- *Fund research to improve detectors.* Low-cost networking and low-cost sensors should be able to provide wide coverage of critical urban areas at a comparatively modest cost. A program should be put in place to find ways of improving upon existing detection technologies as well as improving plans for deployment of these systems and for responding to alarms.

(3) Effective Disaster response

An effective response to a radiological attack requires a system capable of quickly gauging the extent of the damage, identifying appropriate responders, developing a coherent response plan, and getting the necessary personnel and equipment to the site rapidly. The immediate goal must be to identify the victims that require prompt medical attention (likely to be a small number) and to ensure that all other unauthorized personnel leave the affected area quickly, without panic, and without spreading the radioactive material. All of this requires extensive training.

- *Training for hospital personnel and first responders.* First responders and hospital personnel need to understand how to protect themselves and affected citizens in the event of a radiological attack and be able to rapidly determine if individuals have been exposed to radiation.

  There is great danger that panic in the event of a radiological attack on a large city could lead to significant casualties and severely stress the medical system. Panic can also cause confusion for medical personnel. The experience of a radiological accident in Brazil suggests that a large number of people will

present themselves to medical personnel with real symptoms of radiation sickness—including nausea and dizziness—even if only a small fraction of these people have actually been exposed to radiation. Medical personnel need careful training to distinguish those needing help from those with psychosomatic symptoms. While generous funding has been made available for training first responders and medical personnel, the program appears in need of a clear management strategy. Dozens of federal and state organizations are involved, and it is not clear how materials will be certified or accredited. Internet-based tools for delivering the training will almost certainly be necessary to ensure that large numbers of people throughout the U.S. get involved. In the U.S., there are over 2.7 million nurses and over a million police and firefighters who will require training, not to mention the medics in the U.S. armed services. However, there appears to be no coherent program for developing or using new tools to deliver needed services, and to ensure that training and resource materials are continuously upgraded and delivered securely.

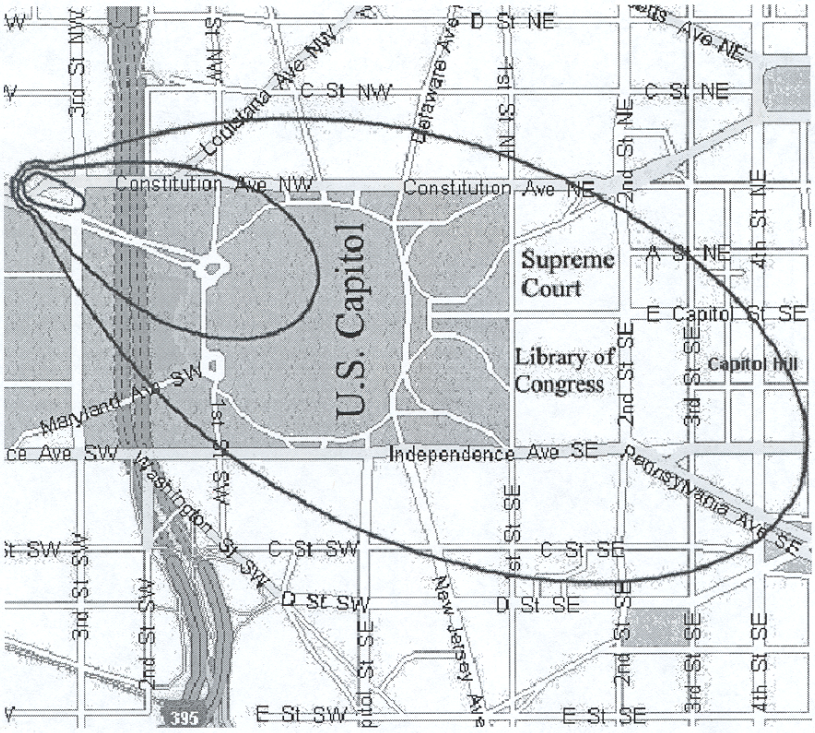
- *Decontamination Technology.* Significant research into cleanup of radiologically contaminated cities has been conducted in the past, primarily in addressing the possibility of nuclear war. Such programs should be revisited with an eye to the specific requirements of cleaning up after a radiological attack. As demonstrated above, the ability to decontaminate large urban areas might mean the difference from being able to continue inhabiting a city and having to abandon it.

CONCLUSION

The events of September 11 have created a need to very carefully assess our defense needs and ensure that the resources we spend for security are aligned with the most pressing security threats. The analysis summarized here shows that the threat of malicious radiological attack in the U.S. is quite real, quite serious, and deserves a vigorous response. Fortunately, there are a number of comparatively inexpensive measures that can and should be taken because they can greatly reduce the likelihood of such an attack. The U.S. has indicated its willingness to spend hundreds of billions of dollars to combat threats that are, in our view, far less likely to occur. This includes funding defensive measures that are far less likely to succeed than the measures that we propose in this testimony. The comparatively modest investments to reduce the danger of radiological attack surely deserve priority support.

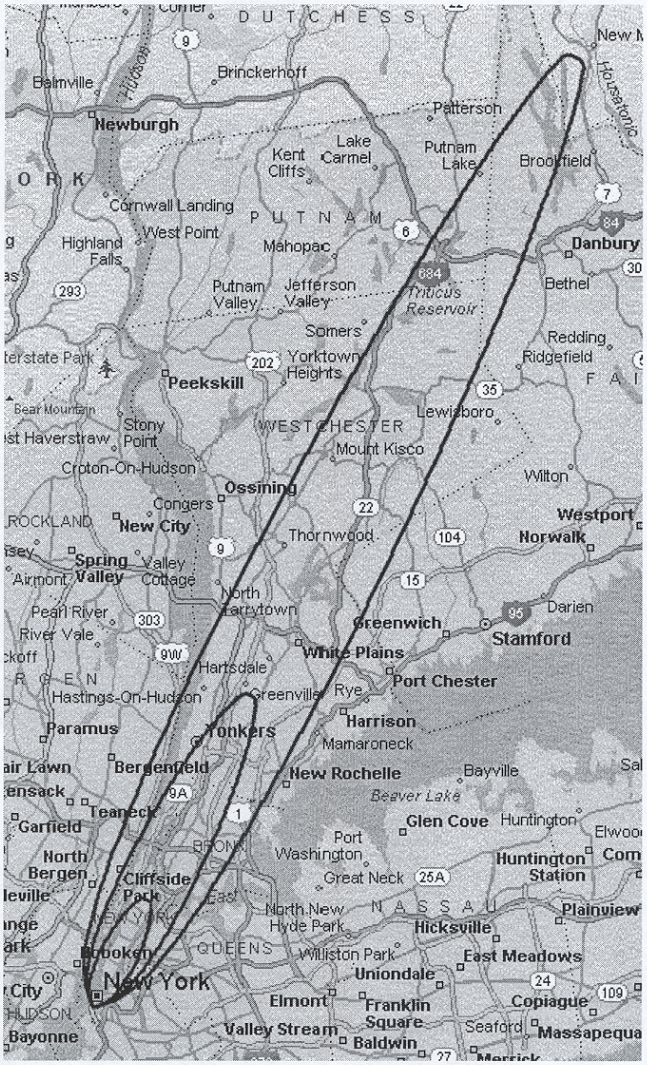
In the end, however, we must face the brutal reality that no technological remedies can provide complete confidence that we are safe from radiological attack. Determined, malicious groups might still find a way to use radiological weapons or other means when their only goal is killing innocent people, and if they have no regard for their own lives. In the long run our greatest hope must lie in building a prosperous, free world where the conditions that breed such monsters have vanished from the earth.

Figure 1: Long-term Contamination Due to Cesium Bomb in Washington, DC



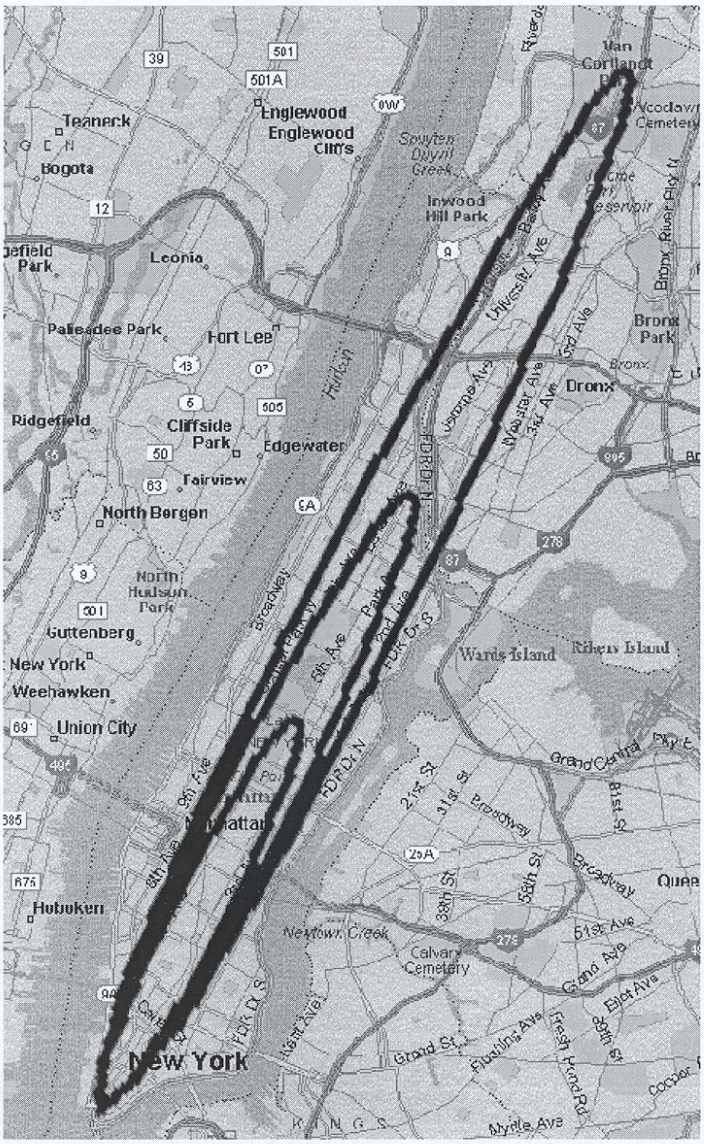
Inner Ring: One cancer death per 100 people due to remaining radiation
Middle Ring: One cancer death per 1,000 people due to remaining radiation
Outer Ring: One cancer death per 10,000 people due to remaining radiation
EPA recommends decontamination or destruction

Figure 2: Long-term Contamination Due to Cobalt Bomb in NYC - EPA Standard



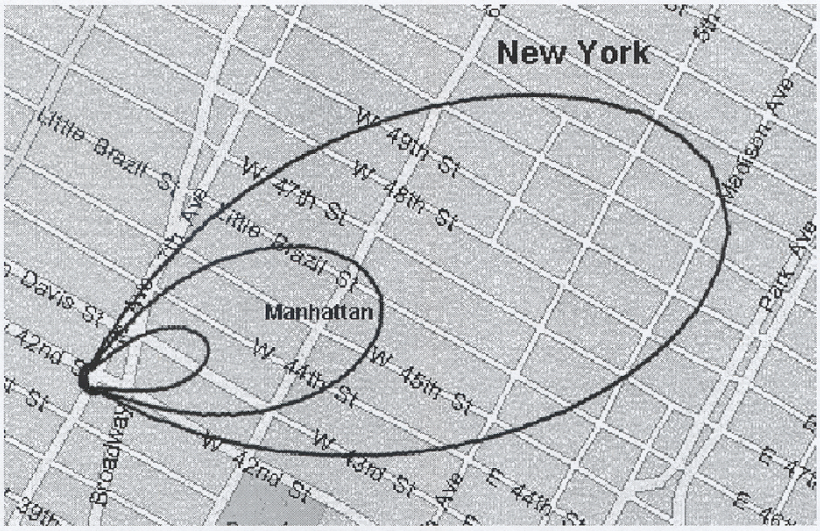
Inner Ring: One cancer death per 100 people due to remaining radiation
Middle Ring: One cancer death per 1,000 people due to remaining radiation
Outer Ring: One cancer death per 10,000 people due to remaining radiation
EPA recommends decontamination or destruction

Figure 3: Contamination Due to Cobalt Bomb in NYC - Chernobyl Comparison



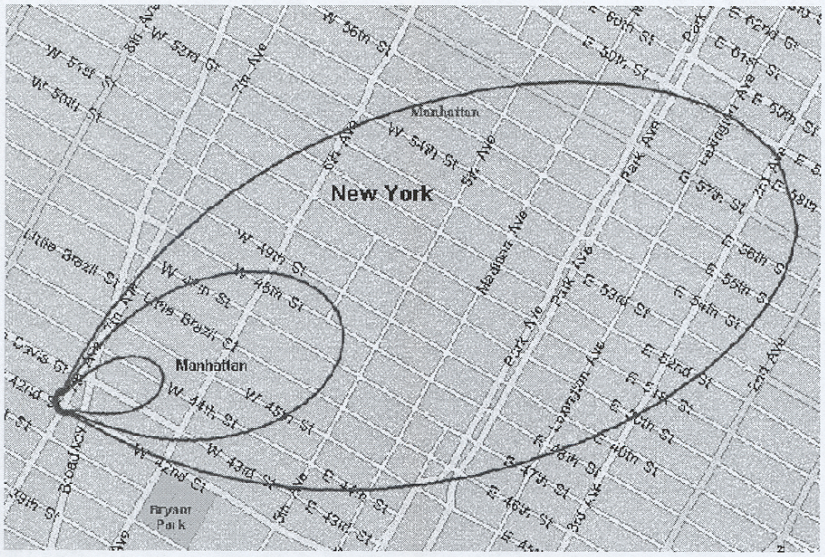
Inner Ring: Same radiation level as *permanently closed* zone around Chernobyl
Middle Ring: Same radiation level as *permanently controlled* zone around Cherno
Outer Ring: Same radiation level as *periodically controlled* zone around Chernol

Figure 4: Immediate Effects Due to Americium Bomb in New York City



Inner Ring: All people must receive medical supervision
Middle Ring: Maximum annual dose for radiation workers exceeded
Outer Ring: Area should be evacuated before radiation cloud passes

Figure 5: Contamination Due to Americium Bomb in New York City



Inner Ring: One cancer death per 100 people due to remaining radiation
Middle Ring: One cancer death per 1,000 people due to remaining radiation
Outer Ring: One cancer death per 10,000 people due to remaining radiation
EPA recommends decontamination or destruction

The CHAIRMAN. Well, thank you, Dr. Kelly. After Dr. Vantine speaks, I have some questions I'd like to pursue with you, as well as Dr. Koonin, on this.

But, doctor, welcome. I indicated this morning, when I opened the hearing, that we had had a very good briefing, in a secure setting. And some of what each you had to say we felt was not prudent to repeat here or was classified and could not be repeated in this setting. And at any time in your presentation, any question that I ask—which is unusual for us to do, but important—that I know what I don't know, and therefore I know you know more than I know—and therefore if you conclude, classified or otherwise, that it is better not to respond to the question in open session, all you have to do is indicate that. I'd appreciate it, and we'll pursue it in closed session.

You all have acknowledged and been willing to come back for the larger session I want to set up for my colleagues, the entire Senate, and the first briefing, more detailed and classified briefing we received. And so we'll have an opportunity to pursue that. But I leave you to your own judgment, and I thank you again for the briefing yesterday, and I'm sure we'll benefit from the testimony today.

STATEMENT OF DR. HARRY C. VANTINE, DIVISION LEADER, COUNTER-TERRORISM AND INCIDENT RESPONSE, LAWRENCE LIVERMORE NATIONAL LABORATORY, LIVERMORE, CA

Dr. VANTINE. Thank you, Mr. Chairman, for the remarks. And thank you for the opportunity to talk before you this afternoon.

By way of introduction, I'm Harry Vantine. I lead the program at the Lawrence Livermore National Laboratory in Counter-terrorism and Incident Response. I've been a member of the Emergency Response Program at Livermore for 20 years, so I have quite a bit of experience in these fields.

As you mentioned, yesterday, in closed session, we talked about the threat to homeland security posed by terrorist use of improvised nuclear devices and radiological dispersal devices. What I'd like to do today is to talk about means by which we can go forward and protect the United States against the terrorist threat. And to that end, I've prepared some written testimony. I ask that that be submitted into the record.

The CHAIRMAN. It will be placed in the record.

Dr. VANTINE. Thank you, Mr. Chairman. What I'd like to do is start out by giving a little bit of background about the current emergency-response program in the United States.

As you know, there are over 40 agencies involved in emergency response and counter-terrorism in the United States, and they all play a role. And the essential progress that we'll make in this country is the progress we'll make by those agencies working together cooperating and coordinating.

One thing that strikes me, though, is that whenever a matter of nuclear expertise comes up, those questions get referred to the Department of Energy. The requests come from many agencies. They can come from the FBI. They can come from State, Transportation. But the Department of Energy is the repository of nuclear knowledge.

We have a program at Energy, the NEST program, emergency-response program, and we try to respond to all requests for information. And to the extent that we can, we do.

Now, the program, as has been talked about this morning, is a volunteer program. We have limited resources. And so when requests come in, we have to prioritize those requests. And the way that we prioritize the requests is by looking at the threat to life that the particular area might pose. For instance, we look at the improvised nuclear device and the biological weapon as those terrorist devices that can cause the greatest loss of life. And so we prioritize—give those the highest priority. There's been a lot of discussion at today's hearing about——

The CHAIRMAN. Doctor, I want to make something clear.

Dr. VANTINE. Sure.

The CHAIRMAN. I'd like you to clarify it, because I think it's an important point that most people don't know. When you're contacted by the FBI, when you're contacted by any of these 39 other government agencies, about the content of the prospect of the particular circumstance that has occurred, that is not included in your yearly budget at the laboratory. That is work done, as you said, on a volunteer basis. Is that correct?

Dr. VANTINE. That's correct, Mr. Chairman.

The CHAIRMAN. Which I think is probably the most astounding and stupid thing that I have heard us do of late, that we do not—knowing that the one place where the expertise resides, we don't provide you—I know you're not here asking for resources, but that we don't provide you the resources so this need not be a volunteer effort. Or am I missing something on that?

Dr. VANTINE. Mr. Chairman, let me explain the rationale. The rationale is that we have major programs at the laboratories looking at nuclear matters. We have the National Nuclear Stockpile Program. We have many experts——

The CHAIRMAN. Which I hope we can keep going, by the way.

Dr. VANTINE [continuing]. In many fields. Thank you. We have experts in many fields in nuclear weapon design, detection, diagnostics, engineering. Those people, many of those people, have volunteered, in the case of a national crisis, to respond. And so when a request comes in, they do respond. So that's the rationale.

With the heightened concern about terrorist use of nuclear materials since September 11, it may be time to revisit that. In the past, that has worked, though.

The CHAIRMAN. Yes.

Dr. VANTINE. Now, improvised nuclear devices, as I said, and biological weapons are at the top of our list. What I'd like to do is spend a few minutes talking about what an improvised nuclear device is and what a radiological dispersal device is.

An improvised nuclear device, as its name implies, is a nuclear device. It produces nuclear yield, and the yield has catastrophic effects. And we talked about some of those effects yesterday. Those effects are generally well known. They're in the open literature. And I think the public has a keen awareness of the catastrophic effects of nuclear weapons.

If you consider what would have happened if the World Trade Center terrorist attacks had been a nuclear attack, the effects would have been much more catastrophic than they were.

The CHAIRMAN. Of the same proportions as it relates to the release of energy. Make the comparison for me.

Dr. VANTINE. That's right. There has been an estimation of the effects of the two airplanes crashing into the World Trade Center, that they carried the chemical equivalent of a kiloton of energy. Now, normally we don't express chemical energy in kilotons, because chemical energy is released over a longer time than the blast from a high explosive. But in terms of raw energy, those airliners carried the chemical equivalent of about a kiloton of energy.

If that kiloton had been a nuclear device, the effects would have been immediate and much longer-range. The loss of life would have been at least two orders of magnitude—a hundred times larger, maybe more, so that it would have been much more catastrophic. It just emphasizes, punctuates the point, that nuclear weapons are much more deadly than their chemical equivalents.

The other thing that I would point out is that dealing with the aftermath of an improvised nuclear device would really be horrific. The rescue workers who tried to go back to ground zero would see radiation levels that were just enormous. In certain parts near ground zero, radiation workers just would not be able to reenter. The radiation levels would be too high. Further away from ground zero, there would have to be evacuation because of fallout. So there would be a long-term consequence, a long-term evacuation needed, and clean up. And, of course, clean up would produce enormous quantities of radioactive material that would have to be disposed of, and that would be no mean feat.

So that, in a nutshell, is why we're really concerned about improvised nuclear devices. The effects are tremendous, and loss of life is just enormous.

Now, if a terrorist decides not to pursue the idea of building a nuclear device and, instead, tries to build what has been called a radiological dispersal device, or a dirty bomb, they would try to get radioactive material, as has been described by both Dr. Koonin and Dr. Kelly. This requires the acquisition of radiological material and some kind of a dispersal mechanism. And radioactive materials are used around the world for a variety of purposes—medical, industrial, and research. And standards for handling the material are in place, and the United States has high standards.

But if you read stories in the world press—some of those have been referred to today—controls around the world—those stories in the press suggest that current controls are just maybe not adequate for protecting some of this radiological material.

The effects of radiological dispersal devices vary fairly widely, and they are measured in terms of contamination area, which we've talked about this morning, health effects, and economic consequences. The health effects appear to be small. The economic consequences can be very large. The psychological effects can be very large. These things are hard to quantify, and we certainly need to guard against radiological dispersal devices.

Now, you know, it's interesting. I mean, there are things that we can do. And in the paper that I'm submitting, I'm suggesting some

of those. One of the things that you'd like to do, of course, to guard against both improvised nuclear devices and radiological dispersal devices is you'd like to protect the material. And so if you can protect the material, keep the terrorists from getting it, that's your first measure of protection.

At the next level, you'd like to have some indications and warning. If somebody was planning something, you'd like to see it. You'd like to get some indications of that. One of the advantages that we have is that we understand, if somebody is trying to build an improvised nuclear device, what they have to do, what kinds of materials they need. There are certain signatures and indicators, and we can look for those, and we do look for those.

Going on, search and interdiction is an important area. There are two major areas I'd like to talk about in trying to improve our search and interdiction capability. One is a technology area. We should try to build better detectors. We have ideas for better detectors, detectors that are longer-range, detectors that are smarter, detectors that use computers to try to take the man out of the loop, to interpret the signals coming from the detectors. So better detectors is the first part of the equation.

The second part of the equation is to try to integrate those detectors into some kind of a system. The technology fails if we're just throwing this technology over a wall without anybody to catch it. What we really need to do is integrate these detectors into systems. And so I'm going to propose two ideas for systems here. There are probably others. These two have to do with protecting the borders and protecting the cities.

The idea of protecting the borders, a system that might help to do that is a system that looks at cargo containers coming into the United States. You could put detectors at the cargo sites and try to find these materials before they find their way into the country.

The idea of protecting cities is to look internal to the borders, to look at cities, to put out distributed sensor network systems, networks of sensors that sense the motion of materials and identify the transport and then are hooked into an infrastructure system that allows us to interdict those shipments. So those are ideas in the area of search.

The next area I'd like to talk about a little bit is consequence management. We tend not to think about the consequences of an improvised nuclear device or a radiological dispersal device, because it's not a very pleasant thing to think about. And at that point, there's a feeling of hopelessness. The event has occurred, you've been unsuccessful in stopping it. But we really have to think about that. We have to think about what we do, how we protect the public.

We need to educate the public. We have to understand what stories we would tell the public about what's happened. We can't start looking at the problem when it happens. We really have to look at the problem before it happens. And so we need to do that. The public needs to be educated. There have to be emergency response plans in place. There have to be decontamination procedures exercised and embedded.

And then the final area I think we need to work on is what I'll call forensics analysis or attribution. Here we are, 3 months after

the anthrax events, still don't know who the perpetrator was, still looking for that. That's really not an acceptable position to be in. We need to develop forensic methods to look at the forensic evidence whenever somebody uses a weapon of mass destruction, to go back and understand who did it. And those forensic methods need to be quick, and they need to be precise. And so that's something that we really need to do.

Traditional forensics labs don't handle radiological materials. They don't handle chemical weapons. They don't handle biological weapons. They handle fingerprints, DNA, that sort of thing.

The DOE laboratories have started forensics work looking at weapons of mass destruction. I think that's work that needs to be supported. And we're doing a lot in that area, and I think there's more to be done. I think there's more that we could do.

So let me kind of wrap up and make some points about where we are with improvised nuclear devices and radiological dispersal devices. In my opinion, the use of an improvised nuclear device is a low-probability event, but it is a high-consequence event. And, for that reason, it's a high-risk event, and it's something we need to prepare for.

We've talked about use of radiological dispersal devices. They're dirty bombs. Those are higher-probability events, because the material is more readily available, but they are certainly lower-consequence events.

As September 11 has shown us, we don't know where the terrorists are going to strike. We don't know how they're going to strike. We need to be prepared for all of these events, and we need to be thinking about vulnerabilities in our infrastructure.

I think the most important message that I would try to give today is that there is no silver bullet in dealing with weapons of mass destruction. We really need a layered approach. We need to look at many different systems to counter the terrorist threat. Coordination among the many different agencies is vital. And I have seen a real improvement, I would say, in the coordination among different agencies, since September 11. We are working together, the different agencies. I think we could do more in the future. I think planned exercises and drills is a way to do more.

As has been mentioned many times today, the key to protecting the country against weapons of mass destruction, against INDs, is to protect the materials. And I think no effort should be spared in trying to protect materials, particularly the strategic nuclear materials, out of which an improvised device could be made. We need to look for signatures that people or groups are trying to obtain weapons of mass destruction and try to get some early indications and warning.

And, finally, let me say that I think this area of emergency response is one where we're going to have to make a sustained investment in science and technology to win the war on terrorism. There are too many places that a terrorist can strike. They have too many opportunities to rely on traditional law-enforcement methods. I think technology is going to have to play a part, and I think we're going to have to look for advanced technologies to protect us.

In closing, I'd like to say that we've been aware of this problem of weapons of mass destruction for a number of years. The NEST team goes back 30 years. We've been involved in this program for a long time. We are aware of it. We're committing resources to it. And we've done a lot. And I think since September 11, we've done a whole lot. I think we could do more. I think we need to do more in the future.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Vantine follows:]

PREPARED STATEMENT OF HARRY C. VANTINE, PH.D., PROGRAM LEADER FOR COUNTER-TERRORISM AND INCIDENT RESPONSE, LAWRENCE LIVERMORE NATIONAL LABORATORY

Mr. Chairman and members of the committee, thank you for the opportunity to appear before you today. I lead the program in Counterterrorism and Incident Response at the Lawrence Livermore National Laboratory (LLNL). However, the opinions that I present today represent my views and not necessarily those of the Laboratory or the National Nuclear Security Administration. Yesterday, in closed session, I discussed the threat to homeland security posed by terrorist use of improvised nuclear devices or radiological dispersal devices. Today I would like to focus on what we can do to protect the U.S. against terrorist acquisition and use of nuclear WMD.

Let me start by briefly defining improvised nuclear devices (INDs) and radiological dispersal devices (RDDs).

IMPROVISED NUCLEAR DEVICES

An IND, as its name implies, is a nuclear explosive device. It produces nuclear yield, and this nuclear yield has catastrophic effects. An IND is the ultimate terrorist weapon and terrorist groups are actively attempting to acquire nuclear weapons. Detonation of an IND could dwarf the devastation of the September 11 attack on the World Trade Center.

Dealing with the aftermath of an IND would be horrific. Rescue efforts and cleanup would be hazardous and difficult. Workers would have to wear full protection suits and self-contained breathing apparatus. Because of the residual radioactivity, in certain locations they could only work short times before acquiring their "lifetime" dose. As with the Chernobyl event, some rescue workers might well expose themselves to lethal doses of radiation, adding to the casualty toll. Enormous volumes of contaminated debris would have to be removed and disposed of.

RADIOLOGICAL DISPERSAL DEVICES

If a terrorist group decides not to pursue an actual nuclear device, it might well turn to RDDs or "dirty bombs" as they are often called. RDDs spread radioactivity but they do not generate nuclear yield, The fabrication of an RDD requires radioactive material and a dispersal mechanism. Radioactive materials are used all over the world for medical, industrial, and research applications. Standards for safe handling and accountability of radioactive material vary around the world. Stories in the press suggest inadequate controls on radiological materials in parts of the world.

The effects of an RDD vary widely, and are measured in terms of contamination area, health effects to the exposed population, and economic consequences. Even a negligible, but measurable, exposure would exploit the general public's fear of things radioactive and have significant psychological consequences. The greatest impact of a small release would probably be economic, associated with cleanup and restoration of the contaminated area.

MULTILAYERED DEFENSE AGAINST INDS AND RDDS

So, what can we do to protect the U.S. against terrorist acquisition and use of INDs and RDDs? As with every other aspect of the terrorism problem, there is no silver bullet. A layered strategy is required, addressing the various stages on this threat.

Weapons and Material Protection

Since acquiring the nuclear materials is a prerequisite to the fabrication of an IND or RDD, first and foremost we must protect nuclear weapons and special nuclear material. Extensive safeguards are in place in this country to protect weapons-

usable nuclear materials; Security at weapon storage sites is rigorous. The NNSA's Material Protection, Control, and Accounting (MPC&A) program is making essential enhancements to the security of nuclear materials at dozens of sites across Russia.

Switching to commercial radiological and nuclear facilities, two threats need to be considered. One is the theft of materials by terrorists and the other is attack on a facility to disperse radiological or nuclear materials. Facilities may include reactors, waste and storage areas. A high-level risk assessment should be performed of U.S. and relevant foreign radiological and nuclear facilities to provide an integrated national view of vulnerabilities. This high-level assessment and analysis of proposed controls would supplement and update current assessments. It would include additional research and development needed for protection. This summary assessment and corresponding recommended measures should be distributed to appropriate agencies/facilities for implementation.

The September 11 terrorists clearly demonstrated considerable technical innovation, excellent operational security, and extensive financial backing. We should therefore conduct enhanced threat assessments that include some threats beyond the current design basis threat. These outside-the-box threats should be analyzed for high-risk or strategic potential targets, based upon likelihood and consequence. The results would be used to guide intelligence gathering and enhance protection of sites and facilities.

Indications and Warning

As always, accurate and timely intelligence is critical. The September 11 attacks demonstrated the extraordinary difficulty of this task, particularly when faced with a diffuse organization that practices excellent operational security. We must be alert to signatures of terrorist IND activities. Significant indicators may be available but difficult to identify either because they are embedded in massive quantities of background information or because it is difficult to share analysis results between different user communities. Improvements in data mining/extraction techniques will offer important advances in the out-years. The utilization of existing national laboratory resources could significantly enhance in the near term the identification of terrorist intentions. Terrorists formulate their own attack plans and strike where and how they choose. However, with nuclear weapons and INDs there are limits involving design, materials and fabrication that must be met in order to produce a nuclear yield. This is the realm of the national design labs and we are able to identify some early indications of a terrorist group attempting to go nuclear.

The NNSA's Nuclear Assessment Program provides a national capability to expeditiously assess the credibility of nuclear threats. Decision makers at the FBI, in concert with their counterparts at the NNSA and NRC, use these assessments together with other information to determine the appropriate response. Since the program began in 1977, we have assessed the credibility of more than 75 nuclear extortion threats, 30 nuclear reactor threats, 20 nonnuclear extortion threats, and nearly 1000 cases involving the attempted illicit sale of alleged nuclear materials. Since September 11 alone, this program has evaluated 13 nuclear extortion threats, 1 nuclear reactor threat, 24 nuclear smuggling cases, and 23 nonthreat incidents.

Search and Interdiction

We need to be able to detect and intercept INDs and RDDs before they reach their target, preferably before they enter the U.S. This element alone requires layers within layers. The DOE Second Line of Defense (SLD) program is assisting Russia's State Customs Committee in detecting and intercepting illicit traffic in nuclear materials, equipment, and technology across the 35,000 miles of Russia's borders. Information from this and similar efforts should be used to enhance existing nuclear smuggling databases, providing linkages among prior scams, materials, regions and intermediaries.

Protection at U.S. borders or ports of entry should be enhanced. Maritime shipping is a particular concern, with nearly six million cargo containers entering the U.S. each year. Technology can play an important role here, with improved detectors at border crossings, and "smart" transportainers with built-in nuclear, chemical, and bioagent detectors. The Labs are exploring improvements in port security including building a test bed for cargo container technology.

While the problem of complete protection for large metropolitan areas remains difficult, it is possible to install correlated sensor networks around key facilities and approach routes. Prototype systems have been studied, developed and shown to work. These prototypes will help lay the ground-work for development of effective approaches for more complex deployment. Multiple organizations are/will be engaged in these types of efforts; communication regarding these activities will be essential.

Crisis Response

Should we fail to intercept a terrorist IND or RDD, the next layer of defense is crisis response. We must locate the device and render it safe. Established U.S. capabilities exist, most notably the Nuclear Emergency Search Team or NEST. NEST capabilities include search and identification of nuclear materials, diagnostics and assessment of suspected nuclear devices, technical operations in support of render-safe procedures, and packaging for transport to final disposition. NEST personnel are drawn from the U.S. nuclear weapons complex, and NEST personnel and equipment are ready to deploy worldwide at all times.

In the current threat environment the NEST program takes on a more critical role. Funding for research and development needs to keep pace with the changing threat environment. Also, additional personnel will need to be recruited and trained.

Consequence Management

In the event of a domestic nuclear event, consequence management assets would be deployed. The NNSA has an established capability for predicting the transport and dispersion of materials released into the atmosphere, including radionuclides. Most important here is knowledge about the probable transport and distribution of prompt effects (blast, thermal, radiation) and delayed effects (fallout). The Atmospheric Release Advisory Capability (ARAC) is a national emergency response service for real-time assessment of incidents involving nuclear, chemical, biological, or natural hazardous material. Since it was established in 1979, ARAC has responded to more than 70 alerts, accidents, and disasters (including Cosmos 954, Three Mile Island, and Chernobyl) and supported hundreds of emergency response exercises. Emergency managers use ARAC plots to develop the best response strategy for minimizing hazards to life or health and property damage in affected regions.

Efficient emergency response will require a capability for promptly predicting the dose to the population as a function of location relative to ground zero and time after the explosion. Such a capability is also essential for rescue teams and others who must enter the contaminated area. ARAC's dose-factor database contains dose conversion factors for internal and external exposure to all radionuclides. ARAC results include plots of material deposited on the ground, instantaneous and time-integrated doses, or air concentrations at selected levels above the ground. Contours are overlaid on maps with features proportional to scale, from buildings to streets to cities to countries.

Decontamination procedures, including a framework for assuring public confidence in the adequacy of cleanup, need to be exercised and vetted. Incident site monitoring capabilities may require enhancement.

A mechanism to ensure that decision-makers are familiar with the Federal Radiological Emergency Response Plan should be developed and implemented; a protection guide for the public needs to be developed because written guidance addressing a terrorist event is negligible. Plans are needed to prepare for a large-scale incident requiring long-term deployments of personnel (potentially at multiple locations) and significant laboratory analytical capabilities.

Attribution

The final layer of defense against terrorist use of INDs and RDDs against the U.S. is the threat of retaliation. Effective retaliation requires accurate attribution of the device—its nuclear materials and device design as well as the perpetrators and their suppliers, intermediaries, and sponsors. A key technical component is forensic analysis of post-detonation debris. The NNSA laboratories, in coordination with a DOD sponsor, are working to enhance the timeliness of the current attribution capability.

A related need is the development of a comprehensive forensic-type database of nuclear materials worldwide.

CONCLUSIONS

Terrorist acquisition and use of an IND against the U.S. is a low-probability, but high-consequence threat. The use of an RDD is a higher probability, but lower consequence event. As September 11 so chillingly demonstrated, today's terrorists are technically innovative and resourceful, financially well supported, actively attempting to acquire weapons of mass destruction, and intent on causing mass casualties and wide-scale devastation.

Let me note that important elements of a layered defense against the threat of terrorist INDs and RDDs are already in place. Coordination among the many agencies involved in Homeland Security is improving and continues to be vital. However, with such a complex problem, more needs to be done.

We must protect the key materials for fabricating an IND—full-up weapons, weapon pits, plutonium, and enriched uranium—both in the U.S., in Russia, and in the rest of the world.

We must watch for signatures of individuals or groups attempting to obtain materials or components of INDs.

Last, but most important, we must make a sustained investment in the science and technology needed to win the war on terrorism. Pulling resources from other important programs is "robbing Peter to pay Paul" and is not a effective long-term strategy. Programs in nonproliferation, proliferation detection, counterterrorism, and homeland security are closely linked and must not be selected "either/or" or conducted in isolation from each other.

In closing, let me assure you that we at Lawrence Livermore National Laboratory have long been concerned about the terrorist nuclear threat. We have built on our historical nuclear weapons mission and developed unique expertise, capabilities, and technologies to meet these emerging threats. LLNL is already providing critical elements of the nation's defense against nuclear, chemical, and biological terrorism, many of which were called into action post-September 11. We are committed to using our worldclass scientific and technological resources—people, equipment, and facilities—to meet the nation's national security needs today and in the future.

The CHAIRMAN. Thank you very much, doctor. Let be begin with you, and then I want to talk a little more about nuclear devices, improvised nuclear devices, and then go back to radiological devices and dispersal means.

As I said yesterday, you showed us a much more detailed outline as well as graphic material. And I don't want to trespass on anything that is classified, but I think it would be useful for the record to know whether or not in your counter-terrorism and incident-response efforts over the last many years, have you and your colleagues at Livermore—have you attempted to go through the process of constructing, doing the engineering that would be required for—you obviously know how to make nuclear weapons, but, I mean, have you gone through the engineering requirements, minimal requirements, that would be needed in order to be able to have a reasonable probability that if a terrorist had plutonium or enriched uranium, what is the most crudest, most workable weapon they could construct? I'm not asking you to describe it to me, but have you all looked into that to try to figure out what we should be looking for?

Dr. VANTINE. Senator, we have looked at that, in a sense. We periodically do exercises and drills in the emergency response programs. And so for those drills, on occasion, we will ask our designers to build what they consider an improvised nuclear device. Now, there's a problem, because these are often experts in the field, and so they don't think like a terrorist.

The impediment to doing this in a more rigorous way is that you don't want to take people who are untrained in the business to ask them to do this, because, in some sense, you'd be educating them to the problem. So you have to approach it very carefully.

I think it's a good point that you bring up, that, in fact, if you want to look for surprises, if you want to look for innovative ideas, you probably should, in a systematic way, ask people who are not trained in the area to do this.

The CHAIRMAN. And the second point that—you state what has been repeated by others, including your former colleague, Dr. Agnew, at Los Alamos, that—and I'm paraphrasing him, but quoting you—"low probability, high consequence." And what I was trying to get at this morning, because I think it's important that

policymakers know and that the American people know so we can have a rational debate in allocation of resources as to what our priorities are in which we seek to deal with first, what threat—the threat assessment is the phrase that is used in your business, as well as over at the Pentagon—and for us to make some rational judgments on what our priorities should be.

And as I understand it, there are, in terms of an improvised nuclear devise, the, hopefully, most difficult part of the process is gaining access to the material that goes boom, gaining access to the enriched uranium or plutonium or fissile material that would cause a chain reaction—a nuclear explosion, correct?

Dr. VANTINE. That's certainly true, Senator. If you can't get access to the materials, there's no further progress.

The CHAIRMAN. Alright. Now——

Dr. VANTINE. They need that.

The CHAIRMAN [continuing]. The reason I raise this is that there has been a good deal of discussion about the existence of the safeguard capabilities that exist in the United States relative to that kind of material. In my private briefings, in classified briefings, and in this open discussion, there is, at least in my assessment—I don't suggest I've surveyed every person who has any knowledge, but there is a fairly broad assessment that is in sync that says that we are pretty darn confident about our ability to safeguard our—meaning U.S.—weapons-grade material. But there is—and I'm not going to ask you to comment in any detail—but there is a diminished—in some cases, significantly diminished—confidence in the ability of other nations that possess weapons-grade material to guard that weapons-grade material from access to someone unauthorized.

Now, one of the things that—and I'm trying to make this not only—I've been doing this a long time; I think I understand it—but I'm trying to recall the dilemma I had in understanding the process when I was first exposed—no pun intended—first exposed to this subject. And that is the first thing I wondered about was how—in what form can this material be acquired or stolen? For example, does a terrorist, assuming they had access to enriched uranium or plutonium in Russia—they gained access to a not-sufficiently guarded—now, I want to make it clear, I am not suggesting, and no one has suggested to me that the Russian Government has anything other than the highest interest in making sure no one has access to this material, so I'm not implying when I say Russia is the "candy store" that the Russian Government in any way has been part of, is considering, has any desire that anyone have access to this material other than the Russian Government and Russian-Government personnel.

I know that sounds like stating the obvious, but there's an old expression from a friend of mine, "Assumption is the mother of all screw ups." I don't want to make any assumptions here, because they can be dangerous.

But having said that, assuming that a person with a mal-intent—whether an individual or an organization, whether it's al-Qaeda or an organization that has yet to be spawned—gained access to the—not a constructed weapon, not a weapon, period, but to enriched uranium or plutonium. How do they gain access? Do

they have to have an expertise? It's not like walking in and saying—if I'm a terrorist and I'm part of an international network and I buy off someone in Russia and they sell me a small nuclear device, I can put it in the back of a truck, I can put it—depending on how big it is, I can put it in another container, I can transport it, and I can do it without any danger other than I may get shot transporting it, but it won't be because, by my touching it, by my putting it in the truck, I am going to be contaminated.

What about the actual raw material—and it's not raw, because it's been—it's acted upon. But what about plutonium? How does that occur? Is that a difficult thing, even if you have access, to take it from its source and transport it to whatever destination you desire for purpose of making an improvised nuclear device?

Dr. VANTINE. Senator, let me answer that by way of relating some of the findings of the DOE's Nuclear Smuggling Program. The Department has a program to look at smuggled sources, if you will, smuggling. And what they find is that there are a significant number of what I'll call "scams" on the market. So there's a lot of misinformation out there. There's a lot of uncertainty about, "Whether this is nuclear material," by people who really aren't educated as to what they have or what they think they have or are trying to make a fast buck for something they don't have. So there's a lot of misinformation out there.

The CHAIRMAN. Well, that's good.

Dr. VANTINE. That is good. But I'm not sure that addresses your question, but it shows that, indeed, there is some difficulty on people's part understanding what they have and how important it is, how vital the material they have might be.

The CHAIRMAN. I guess what I'm trying to get at is this. If someone were to steal, purchase, acquire radiological substance. That is, what you showed Dr. Koonin, that—I forget how many pounds it was——

Dr. KOONIN. Fifty pounds.

The CHAIRMAN [continuing]. A 50-pound device used for a legitimate commercial purpose—were it not shielded, it may admit, depending on what you are acquiring, a lethal dose of radiation, rendering you too ill, and eventually die, to be able to fulfill your mission if you had to do an engineering feat to construct something to put it in to make it do something that would be dangerous to society. Is the transport of plutonium as difficult if you are in contact with it? Need it be shielded?

Dr. VANTINE. I don't want to go too far with this, Senator, but——

The CHAIRMAN. OK.

Dr. VANTINE [continuing]. But let me say that with proper precautions, shielding and distance from the source, these materials can be handled. How easy or hard it is, I'd rather not get into that.

The CHAIRMAN. And the reason I ask is, it seems to me—and one of the things we, in the closed session, I'm going to ask my colleagues to listen to you at another time—I mean all 99 of my colleagues at some forum or another—is to try to get a sense of whether or not the low probability is a low probability throughout the process. It's a low probability you're going to get to the point

where someone is going to make available to you this material, even in the former Soviet Union, hopefully. Second——

Today's my day for Presidents. Excuse me. It's the President of another country. I apologize. I lost my train of thought.

There is the process of acquiring the material. There is the process of transporting the material. And then is there a requirement that the material would have to be put in a different form than acquired in order to make it applicable or be able to be used in a device that would be designed, engineered to make it explode, to cause a nuclear chain reaction?

Dr. VANTINE. Mr. Chairman, I understand the question, and I'd be glad to respond to that in a closed session.

The CHAIRMAN. OK. Now, I think I'm right at the end of my string of what we can talk about in an open session. I recall what the other thing I wanted to ask you is.

Are you able to discuss this at all in an open session? What are the signatures and indicators of the presence of or the attempt or the circumstances that makes the lights go on that would make government officials say, "This group, based on this signature, based on"—as I understand what you mean by signature and indicators—"is a group that appears to be pursuing an effort to build, acquire, and/or construct an improvised nuclear weapon?"

If I can make an analogy, I have some considerable experience in the drug field for doing this for so many years. There are certain precursor chemicals that are obvious if they're present what the individuals involved in the drug business are about. And it relates to whether or not they're making methamphetamine or cocaine or heroine. Is that what you mean by signature? What do you mean by "signature" and "indicators"?

Dr. VANTINE. Normally when I talk about signatures, I mean precisely what you just mentioned, Senator. When somebody is trying to produce biological or chemical weapons in particular, there will be chemicals given off in the production process that perhaps we can look for.

In the nuclear business, there is some of that to some degree, so that when somebody is trying to work with materials that might go into a warhead, they might have to deal with certain materials, and we can look for indicators that they are working with those materials.

In a general sense, let me say that, in working with nuclear—trying to develop either a radiological or a nuclear warhead, you look for people, you look for information, and you look for equipment. So you can look for the kind of people that maybe are working on this. You can look at people with various degrees—in the case of nuclear, nuclear engineering—look for the kind of sources they might use, look at resources from the Internet, resources from the library that they might collect. So you look for the people. You look for the knowledge. I touched on that. People who are interested in—you know, in the case of the World Trade Center, flying airplanes, but not know how to land them. So you look for pieces of intelligence that tells you somebody's out there looking—seeking information about how to build something.

And then you look for the technologies, if somebody is buying equipment that could be used in the construction of nuclear de-

vices. This morning we talked a little bit about radiation detectors. If people are buying who don't seem to have a reason—a normal reason to buy that—so you can put all this together. I think these are all signatures, in a broad sense.

The CHAIRMAN. Without naming them, are there certain metals—if you were aware that I was purchasing certain metals or certain devices that would be categorized as elements of my engineering process to construct a device, not the material, are there certain obvious telltale signs that would raise a red flag if you knew that so and so went to such and such a supplier and purchase *x* amount of a particular metal or a particular anything else, are there those kinds of things that are—are there basic elements that are required to construct a device that are essential?

Dr. VANTINE. There's no one path here. There's no one solution that we look at. There are multiple paths forward. So there's not just one indicator, for instance.

Coming at it from the other direction, a lot of materials are what I'll call "dual use," so they have a legitimate use besides the use of trying to make INDs. So there's no smoking gun in that sense. But I think it's the preponderance of evidence, it's collecting a number of indicators, trying to put the—make composite case out of this and then understanding what somebody is trying to do. That's how we——

The CHAIRMAN. I guess what I'm trying to say is——

Dr. VANTINE. It's a difficult problem.

The CHAIRMAN [continuing]. If you knew that the XYZ Club to Promote Peace and Humanity was buying dual-use items without any reason to believe that they would have a legitimate use for them, that would be—that's an indicator, I assume.

Dr. KOONIN. One dual-use, maybe. Two dual-use items, you get very worried. Three dual-use items, you're very worried.

The CHAIRMAN. Now, what can we do, the U.S. Government, to raise the barriers or raise the stakes that make it more difficult for terrorists to obtain these improvised nuclear devices or basement nukes or whatever the phrase you hear bouncing around. The term of art you all use is "improvised nuclear device." But what are some of the things that we can do? If we first prevent them from acquiring plutonium-enriched uranium, is the game over?

Dr. VANTINE. Let me just second the first point you made. I think the United States has the most serious program to protect strategic nuclear materials, and I think it's in our interest to encourage the rest of the world to have the same standards that we have.

I think once they get—if somebody is known to have materials, I think we ought to try to recover those materials. The game is certainly not over at that point. I think there's a long, rocky road ahead. But at that point, it becomes much more speculation as to where they'll go, and you'll find many strong opinions. There are many detours you can take along the way. There are many wrong turns you can make. There is no guarantee of success at that point. But there is a very heightened state of concern at that point, when somebody has the materials.

The CHAIRMAN. If they have the material. Because as I said—I quoted Agnew this morning, and I'll quote him again, "For those who say building a nuclear weapon is easy, they are very wrong,

but those who say building a crude device is very difficult, they are more wrong." Would you agree with that statement?

Dr. VANTINE. I won't comment on that statement, sir.

The CHAIRMAN. Alright, OK. I think you're really with the CIA. I don't think—or, if not, maybe you're with the Department of Information at the State Department. I'm not sure which, but one thing I do know is you're a first-rate scientist, and I told you I would abide by your concerns of what you stated in open session, and I will.

But in terms of priorities, though, is there agreement that, in a sense, first things first, the single most significant thing we could do to even make the probability of a device being able to be purchased lower than it is at this moment is increase the safeguards surrounding the actual—that weapons-grade material that is in existence.

Dr. VANTINE. Absolutely correct, Senator.

The CHAIRMAN. Good. Well, and have you had a chance, doctor—are you familiar with the Baker-Cutler report?

Dr. VANTINE. Unfortunately, I'm not familiar with that report, no.

The CHAIRMAN. Alright. Well, I'm going to—because I know you have really very little else to do, you're not a busy man—I'm going to send you a copy of the report. And maybe over the next month or so, if I ask you for your response, in open or closed session, as to some of its recommendations, because neither Mr. Baker—Senator Baker—Mr. Ambassador, now, Baker or Mr. Cutler, who are very schooled and aware of matters relating to what used to be called "strategic doctrine," and now we're talking about its—the application of very cruder versions of weaponry in the hands of individuals and not nation states, but they don't have your background on the science side of it, so I'd be interested to see what you thought.

But the safeguarding of the world's fissile material is not the only defense, but it seems to me, from what I've heard today, it may be the best defense. We get the—no pun intended—the biggest bang for the buck if we were able to make it even more difficult. The degree to which we raise that bar, in terms of accessing that material, the degree to which, it seems, increase the lower, even than it is now, the probability of such a weapon being able to be constructed.

Let me move, if I may—my one other question is—apparently—and I don't remember this, but I'm told that Dr. Oppenheimer was asked what resources would be needed to intercept a smuggled atomic bomb. And at the dawn of the nuclear age, he told the Congress the best tool for finding a smuggled atomic bomb was a screwdriver—and that was to open every crate and open every package.

Which leads me to, really, my next—not line, but my next area of questioning, and that is that—and we just touched on it briefly, and I'd appreciate the three of you giving me your best judgment. You indicated, Dr. Vantine, that in order to deal with this, you look at the source, the signature, detection, mitigation, management, and attribution. And not probably in that order. With regard to detection, there has been discussion this morning, and there will be

more discussion about the detection capability presently exists commercially, detection capability that exists, at least in the literature, and detection capability that is on the horizon. And everyone has said we should spend more time and energy and resources in attempting to better that capability.

Now, can you—any of you or all of you—explain, in layman's terms for me—the difference in the degree of difficulty, if there is any, in detecting a radiological weapon and detecting a nuclear weapon, even though it is an improvised nuclear weapon or device. Could you talk to me about that?

Dr. VANTINE. Yes, let me begin with that, maybe. Let's talk about radiological weapons first. By their nature, these radiological weapons are meant to scare people by emitting radiation. So they're fairly "hot" in that sense. In a radiation sense, they're very hot. And particularly before they're dispersed, if there's an explosive or something, they can be extremely hot. And in that sense, they can be detected.

Someone walking down a street—that's one peg point, if you will. People with radiation treatment for medical—people who have medical isotope treatments, generally they can be seen very easily by these detectors. Those sources are very strong in the sense of the kind of detectors that we have. So we can see those.

We do have sensors for looking for nuclear weapons. And, yes, we can see those. They're somewhat harder to see than the radiological weapons.

So there is real potential here to be able to detect these weapons. And we do have prototype detectors that are even better. We have prototype detectors that are very effective at removing background radiation. There's background radiation all around us, but if you can knock down some of that, you can see things much more clearly. So that's a path forward that I think we're almost ready to take. We're almost ready to bring it out of the box.

The other big advantage here, particularly for low-cost detectors, is trying to put some computer software on and trying to include some interpretive software so that when they take their signals, on the spot, they can look and compare what they're seeing to known data bases and relay the message back to someone that—some control point that, "This is what I'm seeing." So those things have real promise in the future.

So I think we're sitting at the dawn, maybe, of a new era. Maybe that's too strong a word, but I think we're sitting at the breakout of new detector technology. So I think it's pretty exciting. We have lots of people working that at the, I'll call, development level—R&D level.

The CHAIRMAN. Thank you. Dr. Koonin.

Dr. KOONIN. Mr. Chairman, I'm not quite as confident as Dr. Vantine is about the detectability of radiological sources. I won't go into the details of steps one might take to minimize their detectability, but I would note that we routinely ship radiological sources through ordinary public transportation channels without setting off detectors.

The CHAIRMAN. Dr. Kelly.

Dr. KELLY. Well, I must say the one thing I think we all agree on is the fact that our detection systems are good, but they could

be a lot better, and that there are many technologies out there that could be tuned to the variety of different materials that will be moving through the economy. And a lot of these materials we're talking about for potential radiological weapons have fairly unique signatures. I think we need to work on that.

Plainly, the highest priority is finding smart systems that are able to bring lots of different sources together. But the more information you've got, the more your computer system can filter out spurious signals from real ones. And I'm sure we all would say that this needs to be a very high-priority research project in the laboratories and elsewhere.

Dr. KOONIN. One last point. As we put surveillance systems of all sorts, and we've seen this with the airport security systems, it's very important that they be constantly tested and "red-teamed" to be effective. Someone must probe the system and someone must be actively trying to defeat the system to make sure we understand its capabilities and limitations.

The CHAIRMAN. We have, as a Nation, supported IAEA programs to provide confidential technical advice to countries that may have nuclear security problems. The IAEA also helps bring radioactive sources under control, as it did in two very dangerous sources in the former Soviet Republic of Georgia earlier this year. How useful are the IAEA programs to help countries improve their nuclear materials security?

Dr. KOONIN. I think they're an excellent place to start. But again, as we've been talking, in this country the change in atmosphere and context of the control of sources shifting from safe-use to perhaps tighter security is something that the IAEA may also want to consider changing its posture on. But it's a very good start.

The CHAIRMAN. Anyone else? Should we support efforts to expand those programs so that we can better address security of radioactive sources? I mean, is that something any of you have any background or expertise in?

I mean, a lot of these things are complicated. As we expand methods to deal with this, we end up with more intrusive practices, and sometimes they are counterproductive, arguably. But is there any instinct you all have about how to proceed, whether we should be looking at that? Or should we be going to a—no pun intended—a different source to get that advice or information?

Dr. KOONIN. There's one international aspect that strikes me here as perhaps worth bringing out. Because of our concerns about security and our economic capacity to do so, we might encourage the shift away from sources to accelerators or neutron generators, and that would be our judgment of the economic tradeoff, versus security. Other countries which might not have as robust an economic situation or might not have the same security situations, might see the balance in a different way. And so it may be very difficult to impose uniform standards of control across all countries.

Dr. VANTINE. I might comment, Senator, that one of the things that I recommended was that in certain areas of our infrastructure we do risk assessments. And I think this issue of shipping practices internationally is an area that we might want to do a risk assessment, to look at the problem, find out if there are particular vulnerabilities, and, once having identified those vulnerabilities,

trying to close them. I think those type of systems studies, in the context of the current threat, need to be done and they should be high priority.

The CHAIRMAN. I couldn't agree with you more, and what I'm about to say, I want the record to show, is not a criticism of the new Homeland Defense Office, nor is it a criticism of Governor Ridge. I think he has an incredible job to undertake, and he is going to find so many bureaucratic roadblocks in his way that it's going to be awhile to sort this out, but it's a good place to start. I am—and I'm not asking for a comment—I am operating under the assumption, because I do not know at this point—I'm operating under the assumption that that very approach is being considered and organized and plotted by this new agency of the government, because it goes back to my central point and, quite frankly, my primary reason for engaging you gentlemen in the first place, and that was that—is that I am—again, as a bit player in the policy process here, I am incredibly—for me, the place that I start and drives my professional staff crazy, is I want that risk assessment. I want that analysis, because I'm being asked to—and occasionally proposing—to spend the taxpayer dollars for purposes protecting them.

And the one great thing about this job—and taking a quote out of context from former Judge Bork is, "This is an intellectual feast." This is the most wonderful job in the world to have if you have intellectual curiosity. You can have at your disposal the best minds in the world. Three of them are sitting at this table, and I get to ask them anything I want to ask them, and I get to hopefully learn something.

But I think there's been precious too little—in this administration, the last administration—precious too little emphasis on risk assessment, risk analysis, and comparative analysis of the priority that should attract our attention relative to the threat and the risk. And that's one of the reasons for this hearing. And there will be more.

Let me ask you, one of the things that you all have spoken about as it relates to all of the questions that have been raised is this notion of mitigation. Once an episode, an event, has occurred, whether it be an improvised nuclear device or a radiological disbursal device—and you've pointed out that we're talking about a standard that exists now, which I believe is one in ten thousand. Is that right? The EPA?

Dr. KELLY. Yes.

The CHAIRMAN. And how, in God's name, do you decontaminate the exterior, let alone the interior, of a building that is—as you pointed out, doctor, the cesium attaches to asphalt, attaches to granite, concrete, I assume glass—maybe not, I don't know—to just anything, any substance. How would—how is that done? And don't say "with great difficulty." Please.

Dr. KELLY. Well, I guess in some of the—there has been considerable experience, of course, after Chernobyl, and particularly the Scandinavian countries that have been downwind have invested very heavily in trying to find ways to mitigate. And it is really, unfortunately, a largely unsolved problem. You can make the matter—one thing they did discover is you can make things worse if

you don't do it right. You can trade a lot of contaminated water that can go under the ground, not something you want to do.

I think that there's a—this is a place which I think—well, you say "with great difficulty"—unfortunately, the way, often, these sites often are decontaminated is by scooping up the dirt and ripping down the buildings. And one would hope that there's a better way. And it strikes me that this is an area where, again, we need to do some fairly careful thinking about what the alternatives are to us.

Of course, there are also procedural things we need to do to figure out how we can make sure we get people out of these places in an efficient way. But, plainly, our highest priority is to——

The CHAIRMAN. Well, if I can—again, I'm just trying to get my arms around this so it's understandable. Assume, for the moment, that we could roll the tape back to September 10, not September 11, and the terrorists set off a 1,000-curie radiation device in lower Manhattan. How would you compare the number of buildings that we'd have to raise compared to what happened, if that's a fair—it may not be a fair question, and there may not be a precise answer. But we'd be taking down a heck of a lot more than the World Trade Towers, wouldn't we, or would we?

Dr. KELLY. Yes, we're talking——

Dr. VANTINE. Oh, yes.

Dr. KOONIN. A thousand curies, we'd be looking at—30 square miles is probably a good fraction in Manhattan if it were disbursed efficiently.

Dr. KELLY. And Manhattan has roughly $2 trillion worth of real estate.

The CHAIRMAN. Say again?

Dr. KELLY. There's roughly $2 trillion worth of real estate——

The CHAIRMAN. Two trillion dollars worth of real estate. Well, I suspect that's the first time we would visit seriously of whether or not the standard——

Dr. KELLY. Indeed, we——

The CHAIRMAN. No, I'm not being facetious. Obviously one in ten thousand is something that is the standard that we would be——

Dr. KOONIN. Mr. Chairman, I wonder, as we think about preparations for this sort of thing, what we can do in advance, I wonder whether some amount of education of the public about the different standards, how they are set, the differences between recommended dose, legally allowed dose, seriously—health hazards associated with doses—might be something that would be worth talking about in public forums more——

The CHAIRMAN. Well, quite frankly, that's the very reason—one of the reasons I wanted to have this hearing, because, as I said earlier this morning, obviously anthrax is a dangerous substance, but before our most recent and, God willing, our only, but not likely, experience with anthrax disbursal, there was a sense that it may have a lethality far beyond what it did. And there was a significant period, and still a question now, of whether or not the lethality of what was released in the envelope that was released in the building adjacent to here, actually connected to this building, was even more dangerous than it was—than had occurred, but because of mitigation at the time, it didn't do as much damage.

But, having said that, I don't think there is the same response out there now. I went home immediately after the first anthrax event, and literally I found reasonable people, understandably in my constituency, close to panic about what was underway. We had great discussions about the issue of the disbursal anthrax through crop-dusting aircraft and the ability to wipe out whole cities and so on. And then we got to the issue of—which I would argue is a little more analogous because of difficulty of acquiring—to smallpox virus and its disbursal and means of disbursal through a self-infected human being, et cetera.

But we began to gather some sense of proportion here. And when you had a case of the bubonic plague in India—in two different cities in India about—I think it was about 10 years ago—there was, in one area—in one of the cities where the political—meaning the governmental apparatus—had sufficient information. They greatly diminished the panic, greatly diminished the damage done, greatly diminished the consequences, compared to the city where there was little information made available to the public.

And so I operate on the premise here that your suggestion—or your question should be turned into a suggestion, that I think we should be doing that. And I would ask, not for you necessarily to respond now, whether any of you or all of you would be willing to submit for the record how one would best approach doing that, from a public policy position, from the position of sitting behind this bench. What should we be doing? Because I think that it is the—I mean, the greatest tool terrorists have is terror. It is inflicting this sense of helplessness upon a society and in many cases designed and if not handled, literally being able to break governmental entities and breed chaos.

So I would very much be interested, doctor, in any suggestions you have, because I think the discussions should be undertaken in light of the fact that it is a—it is, in a sense, the opposite geometry of—political geometry of a nuclear device, which is a low probability and high damage. This is a higher probability and lower-end life-threatening damage that can occur. And to the extent that we educate people, I think we will be doing the country a service.

Rather than keep you all beyond what I have, beyond trespassing on your time, as I've done so far today, is there any comment any of you would like to make in closing here or any suggestions you would have for me or the Congress in how we should think about proceeding as we explore what is obviously a problem, obviously a concern?

Dr. VANTINE. Senator, let me just wind up things by reiterating something I started with, and that is that I think as we look at weapons of mass destruction—nuclear, chemical, biological, the whole panoply of weapons of mass destruction—we always have to come back to—the worse scenario is loss of life. And I think that needs to be put at the top of the list. We need to be concerned with those scenarios where people lose their life.

And I would just close by reminding people that in the Chernobyl incident, which is about the worst radiological release I can think of—maybe there are worse ones, but it's pretty bad—5 percent of the core up in the air, carbon core reactor burning for several days dispersing materials—you look at that accident—30 people died—

they were all radiation workers—as a result of that accident. A hundred and forty people had radiation sickness—again, all radiation workers.

That kind of an event, in terms of loss of life, pales compared to World Trade Center, Oklahoma City, Khobar Towers, Embassy bombings. So I think we need to keep our eye on all of this, but the thing I'm most concerned about is those incidents that cause loss of life.

The CHAIRMAN. Gentlemen?

Dr. KOONIN. I would think, after what we have heard today and in our discussions in the closed session yesterday, you or your colleagues might want to take a hard look at the improvements in safety and security of radioactive sources that might be made in this country.

Dr. KELLY. I would say that the theme that you outlined, which is to try to understand what the risks are facing the country and what the probabilities are and what the consequences are, is something that is seriously needed. And I think what we've done here is to implicitly rank some of these threats.

At the end of the day, radiological weapons are far from the most serious kind of attack that we could have, but it's a very plausible threat, and it's a place where a reasonable investment and a good plan could accomplish a lot.

The CHAIRMAN. The reason why I think people are looking at the—some of us are focusing on the radiological attack. And, Dr. Vantine, I have had a preoccupation with your major concern that absolutely has bored the living hell out of my colleagues for the last 6 years. And I began to wonder—the reason I was so impressed with your testimony is I said, "My God, there's someone else thinking about this," because I've gotten nowhere in trying to raise the consciousness of the prospect, even the raw prospect, of an improvised nuclear device, notwithstanding its great degree of difficulty. And so I understand, and I agree with your, sort of, calibration of the damage and the risk and what we should look at first.

But just as we are looking at cyber-terrorism, we're looking at it for—the two things terrorists seem to be interested in in this country are disrupting our financial and economic systems and, on the other hand, inflicting a significant loss of life as a consequence of terrorist activities. They seem to—there's some evidence to think that those who think about doing us harm are no longer unidimensional, are no longer looking just for, you know, the big bang, although that is the thing that gives them the greatest joy and seems to be the thing they are pursuing with the greatest earnestness.

But the economic impact of a radiological weapon, particularly in the absence of considerable more public education, is one that can have catastrophic consequences for us not resulting in a loss of life directly, but—and I'm not comparing the two in terms of their consequence except to say that the second-tier concern is nonetheless a monumental concern.

But I look forward, if you're willing to doing two things, making your individual and collective knowledge available to my colleagues, as a whole, and, second, to—asking for your willingness to continue to give us advice, in closed session as well as open session,

on how we should proceed, because this is one area that is, in a sense—should be above my pay grade, but, unfortunately, it's not. It should be above the President's pay grade, but it's not. We have to rely on, and we should rely on, the acumen that you all possess in order to tell us, guide us, in how to proceed.

So again, I thank you very much. I apologize for the confusion of the day and appreciate your forbearance. And with that, the hearing is adjourned.

[Whereupon, at 4:35 p.m., the hearing was adjourned.]

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